



# NUTS & VOLTS

MAGAZINE

\$3.50

VOL 17 NO. 11  
NOVEMBER 1996

Exploring Electronics And Technology For The Hobbyist And Professional

## Beaming In Winter Weather Maps And Satellite Imagery On Your PC

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weather storms direct  
from the airwaves!

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The Single Beam

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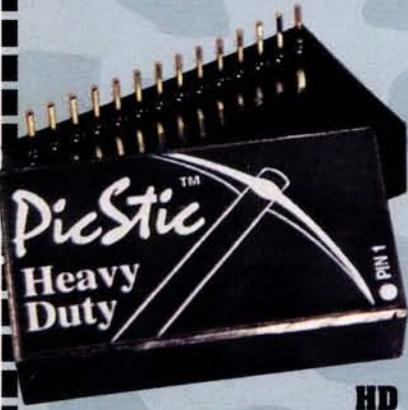


# PicStic™

# Compact Computing with an Attitude!

Happy users might describe PicStic™ as a BASIC Stamp® with an attitude, but we'd like to think that it's just a good idea advanced the way we like it.

PicStics™ are BASIC Stamp® I/O compatible 14-pin boards with a lot of extras. The primary gain is speed and performance. Any PBASIC program you have will automatically run 15 times faster on a PicStic™ using our PicBASIC compiler. Besides getting more speed and double the instruction space, Micromint gives program developers the option of using assembly language, BASIC, or C, along with this enhanced performance.



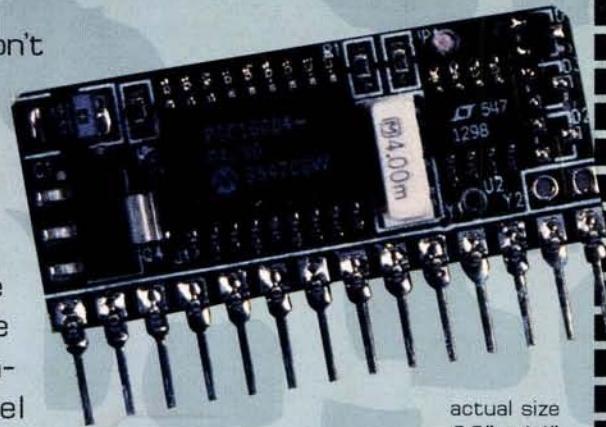
## The Great Coverup!

For our next improvement, we've decided to give PicStics™ a "raincoat" and a "hardhat" to meet those damp or otherwise "crushing" applications. Our "raincoat" is a rubberized dipping process that keeps dust, dirt, and the idiot with greasy fingers from destroying your PicStic. We just call it "Protective Coating." You just order it as the -PC packaging option.

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Small size, high speed, improved performance, lower cost, and packaging with an attitude. That's the new PicStic™.

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Packaging**	14-pin SIP, protective coated or encapsulated	14-pin SIP or encapsulated	14-pin SIP or encapsulated	14-pin SIP

\*Maximum program length and execution speed are determined by instruction mix.

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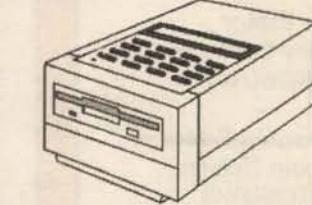
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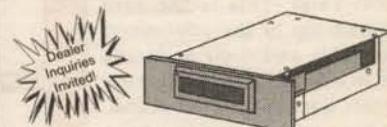
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Jack Lemieux  
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Editor  
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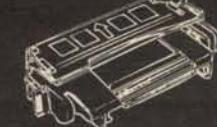
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# reader Feedback

Dear Nuts & Volts:

As a subscriber to *Nuts & Volts* who awaits each new issue eagerly, I'm delighted to see your Web site; it will complement the print edition nicely.

One comment: as a professional Web designer, I would urge you to rethink the enormous (~129 K) graphic at the top of your page. It takes so long to download (even at 33 K) that I'm afraid it will discourage new viewers. I would suggest a much smaller likeness of the current issue so that the viewer can get on with the contents of the site.

Just a suggestion.

Thanks for an informative and really well done publication.

Dan Beach  
Orlando, FL

Dear Nuts & Volts:

I visited your website recently. I downloaded some of Scott Edwards' articles. This is just great, to have these materials available! I really appreciate it! I am a subscriber to *Nuts & Volts*, and I hope there are plans to archive other columns and articles, for future retrieval and use. Having these materials in Adobe format is great!

Steve Roberts

Dear Nuts & Volts:

I am a staunch believer in the use of common non-programmable ICs in home-brew construction articles. You can always find an MC4011 or even far more exotic ICs that perform well, are very inexpensive, easily replaceable, and do not require programming. The circuit may require some ingenuity to

design, but it doesn't require sole-sourced software to work. Nonetheless, I decided to give Terry Weeder's computer interface project ("Telephone/ Computer Interface," Aug. '96) a try (even though \$24.00 for a single IC is almost beyond my comprehension).

I ordered the kit of board-mounted components and discovered upon receipt that no PC board was included — my fault for not reading the ad more closely. After a couple of hours, I had designed, etched, and drilled my own board (single sided with a ground plane on one side). All the parts were installed and the "smoke test" began. The LED flashed as advertised when tones were sent to the board, but no display on the computer monitor (12 MHz 286 w/mono monitor). All wiring and the QB test program were checked numerous times and no fault found. I finally got the board working by changing the "IF INPUT\$ ..." line of the software. I looked carefully at that line and finally concluded that the "O" was infact a capital letter "O" rather than the number zero ("0") which I had entered in my program. That was it!

I suggest to Terry that he change that character to almost any other letter in the alphabet to reduce the confusion. I also suggest that publishers use the slash zero (Ø) to designate the number to reduce the fog factor in technical articles. Software is hard enough to digest without the added confusion of easily misunderstood characters. (The lower case "L" is another character which should be avoided to prevent confusion with the number one.)

The interface worked as advertised and I'm now working to incorporate it into my X10 power line control system.

Robert M. Harkey  
Charlotte, NC

Dear Nuts & Volts:

Thanks a bunch for making the web page and Scott Edwards' excellent STAMP application articles available and for sending me a sample issue of *Nuts & Volts*. You have a great magazine — I'm subscribing!

C.D. Pritchard  
[cdp@chattanooga.net](mailto:cdp@chattanooga.net)

Dear Nuts & Volts:

In reading my October issue of *Nuts & Volts*, I was saddened by the announcement on page 11 of the passing of Anthony Charlton on Sept. 22.

I didn't know Mr. Charlton personally, but have been familiar with his work not only in *Nuts & Volts*, but in many of the major electronic magazines over the years. As an avid electronic experimenter and hobbyist myself, I have always been impressed by the depth and breadth of his projects, and the fact that so many were made available as construction projects.

His passing has reduced the ranks of those writers in the electronic field that have been able to simplify the complex so that beginners and intermediate electronic enthusiasts can gain a foothold in what has become an increasingly confusing and intimidating field.

I'm sure I'm reflecting the feelings of many electronic enthusiasts when I say, "I'll miss you, Anthony Charlton..."

Fred Blechman

Dear Nuts & Volts:

As I read John Iovine's article (Sept. '96 issue) on Flame Speakers, it came to mind that while in college (1970-72) another student and I did a special project (as a freshman) on flame speakers for an Electronics

Continued on page 110

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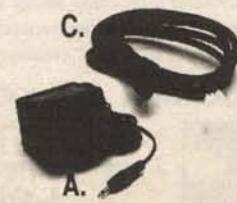
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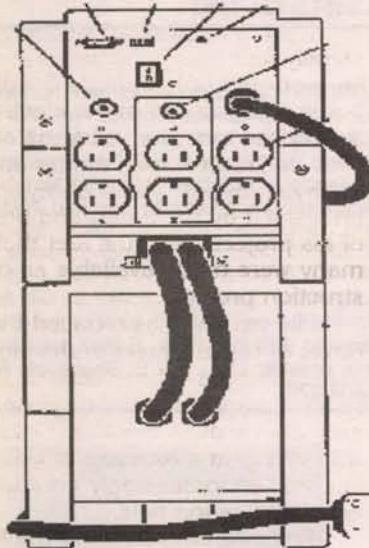
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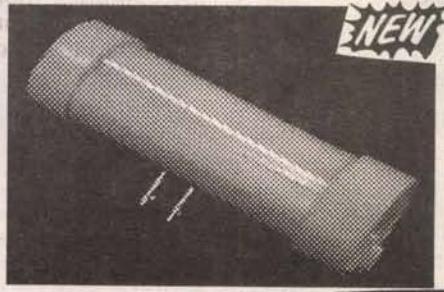
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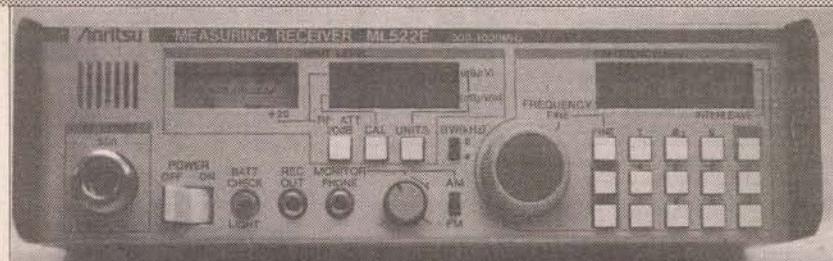
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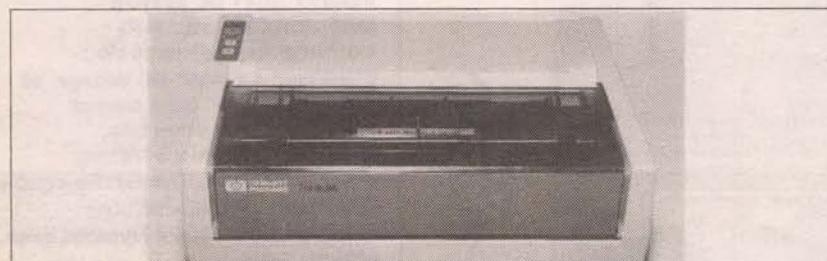
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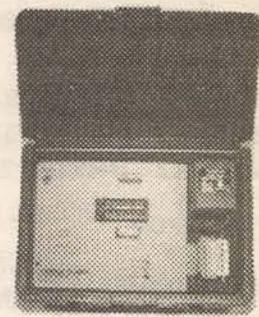
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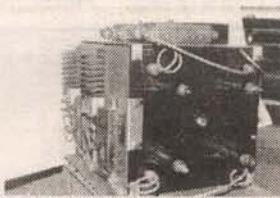
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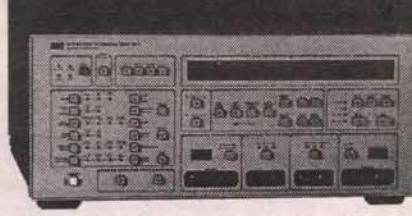
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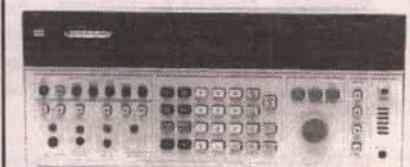
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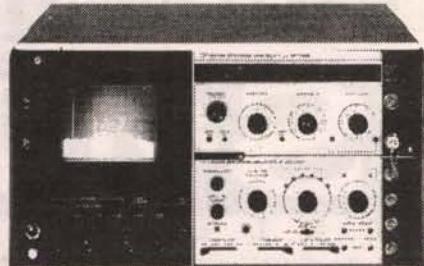
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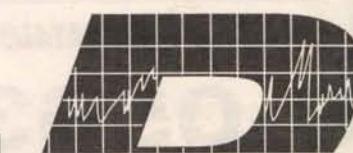
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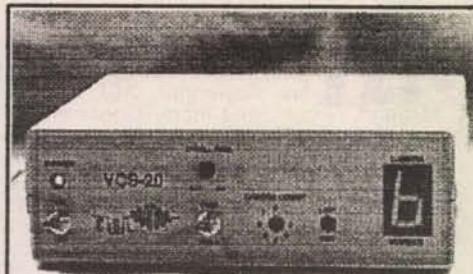
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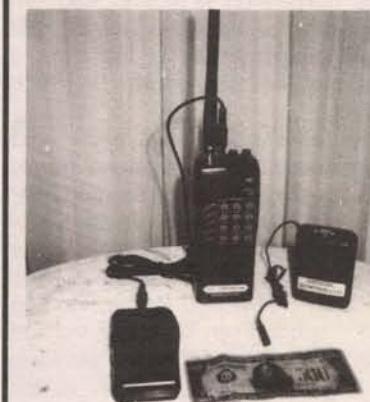


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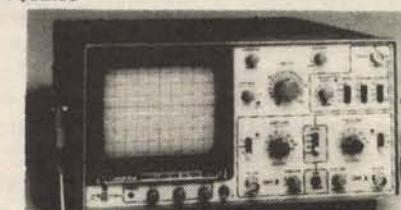
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The second method is to take one ball in each hand and throw the third into the air. Before the airborne one lands, toss one of the other balls in the air and grab the first with your now free hand. Repeat as necessary. Voila! You're juggling. At first blush, this seems like a very poor idea. If you sneeze, or trip, or see something more interesting than what you should be doing, it's balls everywhere.

This is pretty much the difference between stepper motor control and servo motor control. One looks like a no-brainer (or at least a very small-brainer) while the other looks like it requires some sensing, some coordination, and a real-time controller which won't get distracted. But of course, all is not as it sometimes seems, and servo motor control is making inroads into even low-cost applications which were once the exclusive domain of steppers.

#### The Stepper Motor

The stepper motor is essentially a rotating permanent magnet inside a cage of multiple windings. Each winding acts as an electromagnet, so that when it is energized, the motor shaft (attached to the rotating magnet inside) will snap to a preferred position. Energizing a different winding will cause the shaft to snap to a slightly different position. By using a clever arrangement of magnetic teeth on the rotor and on the stationary cage, it is possible to create a large number of stable positions (typically 200 per revolution).

By alternately energizing each of the coils (typically a total of four) in the proper order, the motor shaft can be made to step through each of the successive stable positions. If one coil is left energized, the shaft will hold its position as long as the torque applied to the shaft does not exceed the magnetic forces holding it in place. If the magnetic force is exceeded, the motor will be pushed out of its holding position and will try to lock onto the next holding position for the same energized winding, typically four steps over.

This brings us to the first drawback of stepper motors: If the torque rating is exceeded, the motor will slip steps (with a sort of ratcheting effect), causing two problems. First, the motor is no longer where we want it to be. Second, and often more important, we no longer know where the motor is, leaving us unable to fix the first problem. In fact, we don't even know that the motor has slipped steps in the first place. Even if we did know, the only solution is to move the motor back to some homing position switch so that we can re-establish the zero position of the motor.

The problem of slipping steps may happen because the dynamic loads of accelerating a

# From Steppers to Servos Without Getting Torqued

by Jeffrey Kerr

mass are too large, or because the mechanism attached to the motor shaft ran into something. We can do something about the first case by simply picking a motor large enough so that we will never exceed the torque rating no matter what dynamic load we might see. Keep in mind that the dynamic load may include such highly intractable things as stick/slip friction or a chunk of crud in one of your gear teeth. In general, to have a reliable stepper positioning system, you must pick a motor which is much larger than you might think.

The most general solution to the slippage problem is to equip the motor with some sort of position sensor, and then have a slightly more sophisticated controller which automatically adjusts the step count should the commanded step count not equal the measured position. This solution is actually used with some frequency, although this makes the simple stepper controller no longer as cheap and simple as it used to be.

Now that we have chosen a sufficiently oversized motor, we have to power it. Glossed over in the brief explanation of stepper operation is that when one of the windings is energized, it is energized with the maximum current at all times. Even if the motor has no load on it, it will be sucking up a sizeable number of amps. While this may be the death knell for battery powered systems, it will also propagate into large amplifiers, large wires, and lots of heat for even wall-powered systems.

If we have prior knowledge at all times of what the maximum load will be, it is possible to reduce the motor current at times to a sufficient holding torque, but this sort of solution requires that our higher level intelligence (if we have any) be intertwined with our lowest level of motor control. This is not always particularly convenient.

The stepper motor windings act as inductors, and as such, do not permit instantaneous changes in current. The winding current, however, is what determines the holding torque of the motor. If we do not leave a winding

energized for long enough, it will never get close to developing its full holding torque potential.

To make a stepper motor rotate, the windings of the motor must be energized in quick succession; the quicker we alternate windings, the faster the motor goes. At around several hundred RPM, typically, something begins to happen. Each winding is energized for so little time that the current never has time to build up, and the holding torque starts to plummet.

The assumption has been that when we energize a winding, we simply apply full voltage across the winding. For a six-volt motor, we would apply six-volts. The voltage rating, however, is determined by the continuous voltage which could be applied to the winding without it burning up. The peak voltage may be many times higher. Therefore, more sophisticated stepper motor drivers use a high-voltage chopper driver which pulses high voltage across the winding so that the average voltage (and therefore, current) is equal to the continuously allowable rating. Boosting the supply voltage, however, also proportionally reduces the current rise time, allowing each winding to develop close to the peak holding torque in a much shorter time. The result of this, again, is that the simple stepper controller is no longer quite so simple.

While many applications may not be sensitive to vibration, for those that are, steppers can be a real headache. At low speeds, a stepper motor accelerates rapidly and come to a complete stop with each and every step. It is a nearly ideal vibration generator. To smooth things out, people try everything from rubber mounting brackets to pouring ferro-fluidic damping material into the motor housing. It's usually a pretty ugly problem to solve.

So what we have with the stepper motor is a seemingly simple position control method which, for many applications, has a lot of hidden complexity, and for other applications, some fatal flaws.

#### The Servo Motor System

Back to juggling. The main elements of a servo system are the motor, the position sensor, the power amplifier, the controller, and as with a stepper system, a host computer running the show. Here, we'll just look at the vanilla-flavored DC brush motor with a shaft mounted optical encoder. The DC brush motor has two leads and a clever brush arrangement which causes a positive voltage across the leads to always energize the winding which will push the rotor in the same direction. A negative voltage pushes the rotor in the opposite direction. The torque produced by the motor is proportional to the winding current. The speed of the motor is proportional to the voltage applied minus the voltage drop due to the DC resistance of the winding. (This voltage difference is also known as the back EMF of the motor.)

The incremental optical encoder has a code wheel with slots and two optical sensors looking through the slots. The sensors are aligned such that as the code wheel rotates, they produce two 50% duty cycle squarewaves, typically referred to as Channel A and Channel B, which are plus or minus 90 degrees out of phase. If Channel A leads Channel B, the motor is going forward; if Channel A lags Channel B, the motor is going backwards. The position of the motor is determined by counting the encoder pulses, counting up or down depending on the relative phase. Because each slot produces four signal edges which can be counted, the encoder resolution is four times the number of slots. This type of counting is known as quadrature encoder counting.

Most DC brush motor amplifiers used are PWM amplifiers, which rather than continuously varying the voltage output, chop the full supply voltage at a varying duty cycle and at a frequency of typically 20-30 KHz. Most of these amplifiers take a direct PWM input signal as well as a direction signal, although many also provide for a bi-directional analog input.

The core of a digital servo system is the servo control loop which repeatedly reads the motor position from the encoder counter and compares it to the current commanded motor position. This position error is then input to a control filter which produces an output to the motor amplifier. Hopefully, the output will cause the motor to move in a direction which will correct any position error. With a well tuned control filter, the position of the motor will closely match the commanded position, and the motor torque will exactly balance the load.

For good performance, the servo control loop should be executed at least several times faster than the highest controllable frequency of the mechanical system. For small motors, this may require a servo rate of 1000-2000 Hz. For larger, slower responding systems, the servo rate may only need to be 50 Hz. In general, though, faster is better.

The most common servo control filter is the proportional-integral-derivative, or PID control filter. It produces an output which is the sum of three terms: One directly proportional to the position error; one proportional to the integral of the position error; and one proportional to the derivative of the position error. In a digitally sampled control system, the

integral of the position error is approximated by a running sum of the position error each time through the servo loop. The derivative of the position error is approximated by difference in the position error from one servo cycle to the next. Here we can see that the faster the servo loop, the more accurately we approximate the integral and derivative. The output for each servo cycle,  $O_i$ , is calculated as:

$$O_i = K_p \cdot E_{pi} + K_i \cdot \text{SUM}(E_{pi}) + K_d \cdot (E_{pi} - E_{pi-1})$$

where  $E_{pi}$  is the current position error,  $E_{pi-1}$  is the previous position error, and  $K_p$ ,  $K_i$ , and  $K_d$  are the PID servo gains.

The values used for the three servo gains are picked based on the dynamics of the physical system being controlled. In general, though,  $K_p$  is used to control how fast the system responds and how tightly it can track the commanded position.  $K_i$  is used to reduce the final settling error, and  $K_d$  is used to add damping to stabilize the system. Increasing  $K_p$  and  $K_i$  will make the system more responsive, but increasing them too much will make the system unstable. Increasing  $K_d$  will increase the damping in the system, making it more stable.

Because of the high-servo rates and absolute timing requirements, the servo control loop is usually executed by a dedicated motor control processor. While it is certainly possible to spend an obscene amount of money, there are several inexpensive motor control ICs available to perform the servo loop control.

### The Payoff

Why go to all this trouble? The first thing to note is that we always know where the motor is. If the amplifier blows up, or if a screwdriver is stuck in the gears, we still know where the motor is. If we want to record certain positions by moving the motor by hand, we can directly read the motor position. For systems with any level of intelligence, the position information is invaluable.

Secondly, note that the motor only exerts a torque equal to the load at any

given time. This means that the motor current, and hence, the power, is only the amount required at any given time. For systems which spend a good percentage of their time twiddling their thumbs, this can amount to a huge power savings over stepper motors. In addition, if we monitor the motor current, we are also essentially monitoring the load on the motor. This load information can also be used by an intelligent system to diagnose problems or to detect various operating conditions.

Another more subtle aspect of the power issue relates to the motor and amplifier size. Most motors and amplifiers are thermally limited. For fractional and sub-fractional horsepower motors, their peak torque can be several times that of their continuous rated torque. For most amplifiers, the peak current is about twice that of the continuous rated current. This means that we can size the motor and amplifier for a particular application based on the average requirements rather than the peak requirements. In the case of a mobile robot, for example, the motor would be sized for the average acceleration and rolling resistance for the vehicle, but we would still have twice the current and torque available to overcome the unforeseen bumps in the floor. A stepper motor would have to be sized to accommodate all bumps that might be encountered, regardless of how rare they might be.

The last major advantage to servo control is in the quality of control. Because incremental encoders are of typically very high resolution, low velocity control can be made very smooth and the position can be controlled much more precisely. At the same time, there is no problem operating motors at very high speeds. Because there are three servo parameters which can be adjusted, the motor response can be made to be softer or firmer, faster or more damped, as is required by the application, and even changed dynamically if necessary.

### Designing a Servo Controller

The primary element in a servo system is the servo controller. Here, I am

going to use the PIC-SERVO motion control chipset as a case study, although the design considerations will be identical for any motion control system.

The overriding thing to keep in mind when putting together a servo system is the juggler tripping or sneezing. Failure of any element of the control system, rather than causing the motor to stop, will in all likelihood cause the motor to go berserk. Every element of the system should be designed to minimize the possibility for failure, and secondly, if possible, detect errors and take the most graceful corrective action.

### System Architecture

The first thing to consider is the physical layout of the system you are trying to control. This may not be the most important thing, but because the layout has implications for the fundamental architecture of the controller, it must be considered first.

If you have a physically compact system where the motor (or motors), servo controller, amplifier, and host computer can be placed in close proximity, you are lucky. Wiring and high-current switching noise will not be a big problem. For systems which are more distributed, the traditional control set-up where the host, controller, and amplifier are in one place, and the motors and mechanism in another, a great deal of time and expense goes into getting high currents out to the motors, and getting the digital encoder signals back to the controller past all of the motor noise. In a distributed mechanism, serious thought should be given to using distributed motor control, solving a whole raft of problems.

Keep in mind that the most critical link in a servo system is between the motor and the controller, not between the controller and the host. In particular, wires from the encoder should be as close to the controller and with as few intervening connectors as is feasible. It is not uncommon to get unwanted feedback loops where the encoder signal picks up some motor noise, the controller gooses the amplifier to correct the apparent position error, causing the encoder signals to pick up even more noise. And

we don't even want to get started on the problems associated with connectors.

For just this reason, the PIC-SERVO chipset was designed with a serial command interface rather than a more traditional eight-bit wide bus interface. While the PIC-SERVO or multiple PIC-SERVOs can be placed on a controller board right in your PC, they were really designed so that they can be placed remotely near the amplifiers and motors. For a simple motor controller, an RS232 transceiver chip like the MAX232 is all that is needed to communicate with the host. A diagram of this type of system is shown in Figure 1. For multi-axis systems, the PIC-SERVO may be used with an RS485 transceiver chip to allow multiple controllers to communicate with the host over a single serial port. Multi-axis control systems are inherently supported by the serial interface protocol in the PIC-SERVO firmware. Incorporating all of the serial communications features directly in the servo controller eliminates the need for an additional processor, improving the reliability of the system.

### Trajectory Profiling

Before choosing a processor for the servo controller, the issue of trajectory profiling must be addressed. The servo calculations themselves are not hugely burdensome, but most servo controllers also incorporate some level of trajectory profiling to generate the smooth motions to feed to the servo control loop. Trajectory profiling calculations, particularly for multi-axis systems, can get to be arbitrarily hairy.

In general, we don't want the motor to be lurching from one goal position to the next. Rather, we want the motor to accelerate, slew, and decelerate smoothly. The most common approach to trajectory profiling is to calculate a new command position each time the servo loop is executed. This closely spaced string of command positions should accelerate the motor at a limited acceleration, run it at a constant velocity, and decelerate the motor, causing it to end up at the desired goal position. For multi-axis systems, we may want the motors to behave smoothly in unison to cause a mechanism to follow a specific path.

In principle, all of the trajectory profiling could be done by the host, with the servo controller simply executing the PID control filter. To get a good approximation to a smooth path, however, the command positions must be updated at nearly the same rate as the servo loop. Therefore, most controllers provide at least some level of trajectory profiling which can be used to generate smooth, but simple, motions. For more complex paths

*The PIC-SERVO chipset was designed by J. R. Kerr Prototype Development to support industrial development projects in robotics and machine design. The PIC-SERVO chipset, as well as a low-cost experimenter's board, are now available as products. Please visit <http://users.aol.com/dcservo/picservo.html> for complete documentation, application notes, sample schematics, and ordering information. You can mail any questions about the PIC-SERVO to DCSERVO@aol.com*

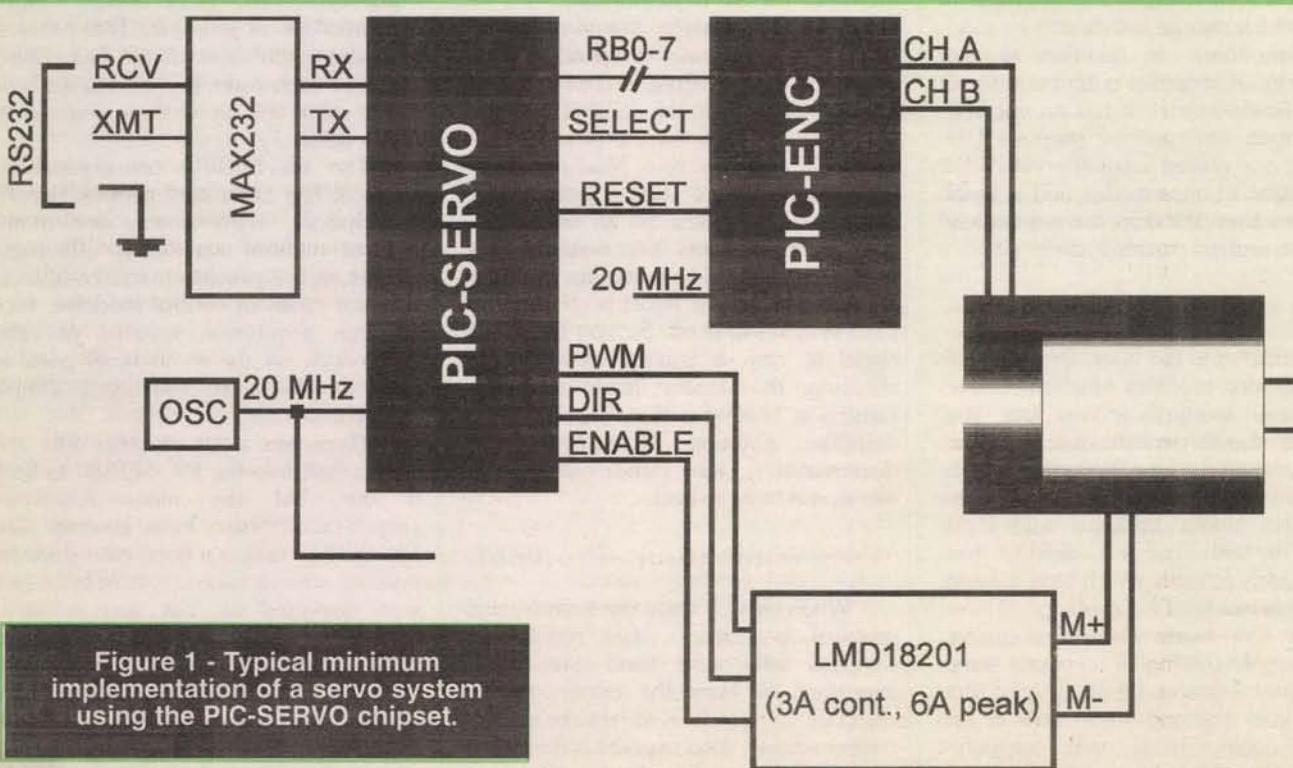


Figure 1 - Typical minimum implementation of a servo system using the PIC-SERVO chipset.

calculated by the host, the host can use the built-in trajectory profiling to reduce the spacing of intermediate command points to something on the order of 10-50 Hz.

The PIC-SERVO contains two fairly straightforward trajectory profiling modes, one for position control and one for velocity control. Position commands cause the motor to execute a trapezoidal motion profile, where the motor accelerates at a fixed acceleration up to a maximum velocity, slews at this constant velocity, and finally decelerates at a fixed rate to stop at the goal position. A plot of velocity vs. time for this trajectory produces a trapezoid. If the goal position is close to the starting position, the motor may have to start decelerating before reaching the maximum velocity, producing a triangular profile instead.

The velocity control mode simply increments the motor's command position at a constant rate to achieve a constant velocity. If the motor is commanded to change velocity, the trajectory profiler will accelerate or

decelerate the motor at a fixed rate until the new goal velocity is reached. This velocity profile can also be used to piece together smooth motion segments for creating arbitrarily complex paths.

With enough resolution in the acceleration and velocity parameters, it is possible to coordinate a number of motors to start and stop at the same time, and move in a straight line in-between. The PIC-SERVO uses 32 bit position, velocity and acceleration registers which provide enough resolution to calculate coordinated velocity and acceleration parameters, even though the individual controllers are operating independently.

### Processor Selection

With the communications interface and the bulk of the calculations determined, it is possible to choose the type processor to use for the servo controller. It is tempting to want to use the host to perform all of the calculations, given that the host may end up doing some of the profiling calculations anyway. The important thing to remember, however, is the extreme real-time requirement of servo control. Any bug, or even unexpected delay, in the large mass of host software may cause your motors to thrash your mechanism (or the person sitting next to it). Given the cost of a dedicated servo control processor as compared to the cost of the rest of the overall machine, I can't imagine many projects so budget bound that they couldn't afford the margin of safety offered by a dedicated control processor.

The PIC-SERVO chipset is an example of just how inexpensive a dedicated controller can be. The chipset consists of a PIC16C73 microcontroller performing the servo control, trajectory profiling and host communications, and a PIC16C54 programmed as a medium speed quadrature encoder counter for encoder transition rates up to 500 KHz. The servo control loop and trajectory calculations can be performed at up to a 2 KHz servo rate with a serial communication rate of up to 115.2 Kbaud. Higher communications rates are possible at lower servo rates. It produces a 20 KHz PWM output and a direction output which can be fed directly to most PWM amplifiers. In addition to the encoder input, amplifier output and serial communications port, it has an encoder index input, two general purpose I/O bits, and one analog input channel. With the addition of an amplifier and a serial interface transceiver chip, it is a complete DC servo motion control system.

### Safety Features

In addition to the basic servo control and trajectory profiling functions, there are several safety functions that the controller should perform directly rather than relying on the host. You pretty much have to sit down and think of every stupid thing that might happen, and then assume it will. The PIC-SERVO has several safety features which tend to keep major disasters from happening.

The first safety element is motor power supply sensing. If someone turns off the motor power supply (leaving the logic power on) and then turns it on again, what will happen? Without any explicit checking,

the mechanism will drift from its formerly commanded position, and then slam back to that position once the power is reapplied. The PIC-SERVO can be configured to sense the presence of motor power, and it will automatically disable the servo output on loss of power. The host must explicitly issue a new motion command to re-enable the servo.

The next safety check is a programmable position error limit. While moving, the motor will always have some small position error, but if the error grows too large, the mechanism may be jammed, and again, the PIC-SERVO will automatically disable the servo output. The position error may be changed dynamically for different operating conditions.

For some mechanical systems, it may be desirable to limit the overall output to the motor no matter what the position error is. For situations where a mechanism may be moving in an unknown space, we may wish to keep from crushing something we might run into. The output limit is also handy if you happen to have a low voltage motor hooked up to a higher voltage amplifier. Again, the PIC-SERVO output limit can be dynamically programmed for the given operating conditions.

In addition to the output limit, it is also possible to use the analog input signal for current limiting. If your amplifier has a current sense output, even a highly non-linear one, it can be connected to the analog input and used to limit the current to the motor. If the measured motor current is greater than the programmable current limit, the PWM output will be reduced until the current level is within the limit.

Current limiting is a particularly useful feature for getting the peak current out of your PWM amplifier. Most amplifiers have internal current limiting, which when hit, will disable the amplifier. The amplifier will remain disabled for a short time before kicking back on. The result can be a low-frequency on-off cycle which produces an average current far lower than the rated peak current. By limiting the PWM output just before the peak current level is reached, the amplifier can operate continuously at this level without fear of kicking out.

The last safety element is an amplifier enable signal independent from the PWM output signal. It is possible for a transistor to fail in the conducting state, causing motion of the motor even with the PWM output at zero. Most amplifiers have an additional enable input which can be used to turn off all transistors. Also, most amplifiers will create different motor behavior depending on whether the amplifier enable signal is off or if just the PWM signal is off. Setting the PWM signal to zero is usually equivalent to shorting the motor leads together, causing a braking action. Disabling the amplifier, however, is equivalent to disconnecting the motor altogether, allowing it to freewheel.

### Communications Protocol

When using a serial communications protocol, particularly when running at standard serial port baud rates, it is important to keep the commands as compact as possible to maximize the command rate. Also required is the ability to communicate with multiple controllers,

individually, or in groups. Finally, the protocol should be fail-safe, allowing the host to send commands at any time.

The PIC-SERVO uses a strict master/slave protocol where commands are sent over a dedicated transmit line and status from all controllers is returned over a shared receive line. Commands from the host are in packet form, consisting of a header byte, an address byte, a command byte, additional command data (as required by the specific command), and a checksum byte. When the host sends out a command, the controller with the matching address will always send back a status packet. After the status packet has been sent, the controller will lower its transmit enable signal to allow other controllers to talk over the shared status line.

The status packet will always start with a status byte and end with a checksum, and in the middle will have a variable amount of additional status data, selectable by the host. Different operating modes may require different status data from each PIC-SERVO. The programmable status data feature is used to minimize the amount of data sent by any controller for any particular operating mode.

The host can also send out commands to groups of controllers. Selected controllers can be assigned a common group address (in addition to their individual addresses) with one of the controllers optionally designated as the group leader. If a command is sent to a group address, all controllers in the group will execute the command, with only the group leader sending status in return. Status of the other controllers in the group is queried individually. The group addressing feature allows for synchronization of several controllers for starting motions, storing positions, or setting global parameters.

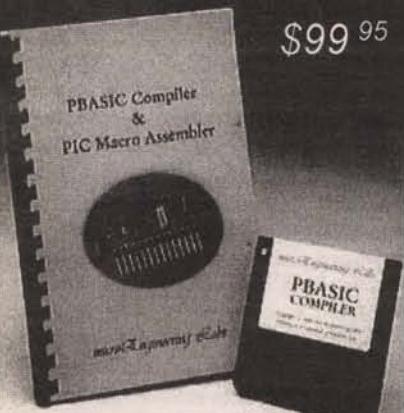
Because the host has a dedicated command line, it can always issue commands to the controllers, even if one of the controllers is running amok. Normally, the host will wait for a complete status packet before issuing an additional command, but even in the middle of receiving a status packet, it can send a new command, causing all controllers to halt any status transmissions in progress. This protocol guarantees that host always has control and that each controller will always have a free status line on which to transmit its status data.

The PIC-SERVO communications protocol has been kept general beyond the specific requirements for motor control without sacrificing efficiency. Therefore, it is possible to mix completely different types of control modules, such as data acquisition systems or relay controllers, on the same serial port, as long as they use the same simple protocol.

There are a lot of other bits and pieces built into the PIC-SERVO to flesh it out, but the more important considerations have been covered. The PIC-SERVO makes a good case study for building a servo control system because it was designed as not just a servo controller, but as a nearly complete servo system. More importantly, it shows that expense and difficulty in creating a reliable servo control system are hardly prohibitive for even the lowest cost applications. NV

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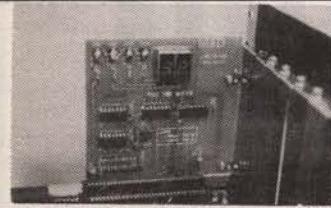
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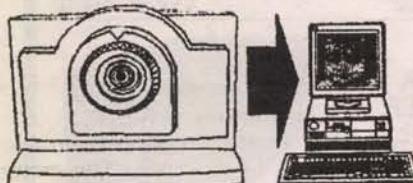
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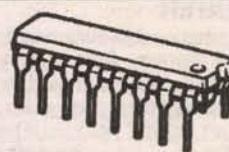
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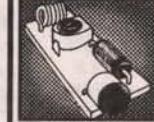


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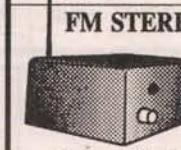


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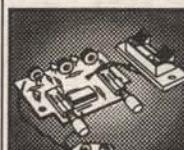
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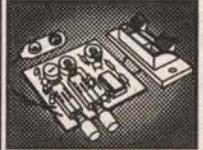


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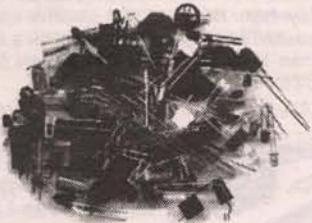


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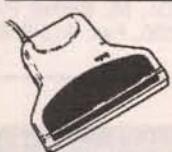
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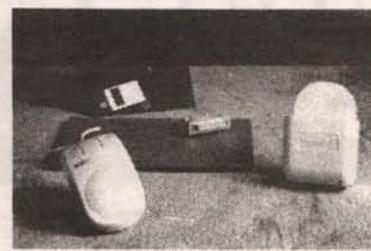
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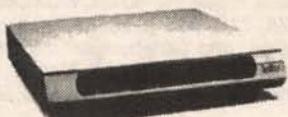
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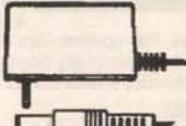
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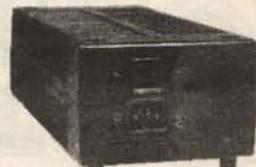
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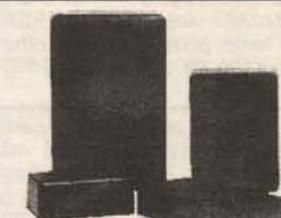
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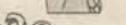
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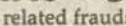
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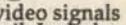
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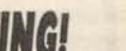
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## Questions & Answers

# TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

## QUESTIONS

I am trying to build a lighting circuit that will respond to my TV remote control from my favorite arm chair. I am told that the remote control sends an infrared signal at some frequency and modulation. Is there an industry standard for these frequencies? What are they or how can I find out? Any information will be appreciated.

**11961** L.B. Williams  
Milton, FL

I am looking for Panasonic Television Maintenance Menu access codes. I know the codes used to access the hidden on-screen programming features (overscan, color depth, etc.) on modern Sony televisions, but have not found the code for Panasonic. The Sony code requires the TV to be off, then press three consecutive buttons on the remote. The TV then powers on in maintenance mode, where overscan (etc.) can be adjusted. Any similar information regarding similar Panasonic features is greatly appreciated.

**11962** John Hentges  
San Diego, CA  
[xalseqsn@sdcoe.k12.ca.us](mailto:xalseqsn@sdcoe.k12.ca.us)

I have a Genie Brand GXL screw drive garage door opener. It is out of warranty and the optical sensor (that prevents the door from closing if the infrared LED beam is broken by an obstruction) does not work. This problem with the optical sensor (OS) has occurred before (following lightning strikes) and bad units from the factory including a bad board. I want to end this recurring headache by eliminating the optical system altogether. Is there a way to bypass this system? The optical sensor system is connected to the control head/motor assembly by low voltage bell wire at two connections. Is there a diode I can cut, or a jumper I can solder onto the board to eliminate this nuisance? The opener will not close, unless manually overridden by the wall switch, unless the OS is functional. Or, is there another solution short of continually repairing the system? I do not have the schematic for the opener. The owner's manual only shows the installer's version and not the board's schematic. Any help from someone familiar with this opener's electronics is appreciated.

**11963** Dean Olson

I like to put flashing LEDs into small flashlights and give them to friends, etc. Because power is minimal, I've found the 3909 LED flasher IC to be ideal. What I have tried to match

with this is a simple circuit that would turn the 3909 off when the lights are on. Everytime I try to use a photo resistor or LED with an OP, I get feedback and it still flashes. Is there a way to do this and not put more drain on the batteries than the 3909 does?

**11964** Mitch Appleby  
Manchester, IA  
[mappleby@mwci.net](mailto:mappleby@mwci.net)

I have a Fisher Price kids video system 1987 and would like to use the video CCD. The circuits hook up to my wireless VCR transmitter. How can I separate the CCD board for this? It is hooked to the main board (with cassette unit). I want to eliminate size for this project.

**11965** Kevin Moe  
Ottaw, IL

How can I apply a varying electrostatic charge to a flat metallic surface, such as a copper clad board or ordinary aluminum flat stock? The charge should be variable so that fine particles would be attracted on the low end up to anything that isn't nailed down on the highest intensity setting. I realize that electronic air cleaners and Van de Graff generators both produce electrostatic fields, but they're not what I'm looking for. However, aspects of both devices may be applicable.

**11966** Daniel Katzenelson  
Willingboro, NJ

I have a HP 540 bubble jet printer. When using Windows 3.11 or Windows 95, a blank sheet precedes the printed sheet. The separator sheet is disabled (Windows 95). I spent 1-1/2 hours on the phone with HP and they were not able to help. Any suggestions?

**11967** Herman L. Dawson  
Ormond Beach, FL

I have a Sony Trinitron color monitor Model KX-1901. I'm experiencing a jailbar effect on the left third of the picture. They are darkest at the left-most and gradually get lighter toward the center. If I turn the color off, it's still there.

**11968** Richard Timby  
Celeste, TX

I have a problem with an IRD unit for a 10' disk. The unit is made by Uniden, model number PS6000XL, and it just suddenly quit working. There's an error message on the screen telling me I have no pulse coming from the actuator. So I went to the dish and checked it out. Everything was fine. The next morning I called Uniden to order a service manual, and was told they don't have one. To make a long story short, the only thing wrong with

it is that the antenna won't move because of this pulse thing. I would like to know if anyone can help me get to the bottom of this, provide a schematic, or tell me what's wrong.

**11969** Frank Mommicco WA2EFV  
Tampa, FL

## ANSWERS

### ANSWER TO #10964 OCT. 1996

The key component to what you want to accomplish is actually the VCR. I have connected a VCR and a portable radio to record radio programs three hours long (eight hours is possible with the appropriate tape and recording mode). The only modification that might be required is to the radio if it does not already have a headphone or earphone output jack. Radio Shack has most of the adapters and cables to make the connection from the radio's output jack to the audio input jack (usually RCA type) of the VCR.

After making the connection between the radio and the VCR, setting the volume control on the radio to an acceptable level, you would then set the timer on the VCR to record at the time and for the duration of your radio program. You would play back the recording through the TV as usual (of course, there would be no video) or use a headphone to listen if the VCR has the appropriate jack. The only drawbacks to this method is that the radio must be left on all of the time, and only one channel per session (the radio must be manually pre-tuned) can be recorded.

**Kevin Goodwin**  
Oceanside, CA

### ANSWER TO #10962 OCT. 1996

The part you are looking for (AN7210) is available from MCM Electronics, 650 Congress Park Dr., Centerville, OH 45459-4072. Their catalog is available for free by calling 1-800-453-4330.

**Kevin Goodwin**  
Oceanside, CA

### ANSWER TO #10965 OCT. 1996

While it is possible to convert from CGA video to VGA, it doesn't make much sense to do so. That is probably why you don't see devices on the market. The CGA format is 640x200 pixels at maximum resolution (there are some lower resolution modes, too). VGA is quoted as 640x480, although the text modes are 640x400.

To convert, you would need a scan doubler. For each field of CGA video lasting 63.5 uS, the scan doubler

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- 1) Circuit Design    3) Problem Solving  
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would output two fields each lasting 31.75 uS. The line doublers that are available for high-end consumer video do this. They are designed for NTSC composite video input, though. CGA is a digital format, with 4 bits per pixel (R, G, B, and I).

The reason it doesn't make sense to convert to VGA is that you don't gain anything. The scan doubler would simply display two scan lines containing the same information for each line of the CGA source. The resolution would still be only that of CGA. All you have created is a higher scan rate signal

# TECH FORUM

that requires a more expensive monitor. A video scan doubler is designed to take interlaced NTSC video and de-interlace it (to eliminate the flickering that results from the 30 Hz frame rate). CGA is not interlaced, so there is no benefit to de-interlacing it. Each field is the same.

If there is a reason other than resolution for this conversion, the way to approach it depends on your level of design expertise. If you are familiar with digital video design, then you understand how to use serial video RAM chips such as the NEC uPD42101 line buffer RAM to make a simple line doubler. The CGA input side is easy since it is already digital. You'll have to use a PLL to generate your

clock, though. If that is more than you want to get into, then another approach is to make a simple NTSC encoder to convert the CGA video output into something close enough to NTSC that a commercial TV to VGA converter would accept it. Look at the Motorola MC1377 for a simple example.

A really cheap and dirty NTSC encoder (just gates and resistors) is found on the original IBM PC CGA (that drove the RCA video output jack). That design relies on a 14.318 MHz clock that is phase synchronous to the pixel clock. You probably don't have a clock available outside the box, though.

**Tim Godfrey**

## ANSWER TO #10961 OCT. 1996

The whole concept of converting monitors got a big boost when I discovered the similarity between a 26 KC model 3179 monitor and a 30 KC model 2115 IBM monitor. At first, I made all the changes, but I found out that many are not required.

PART NUMBER	MODEL 3179	MODEL 2115	NOTES
OLD VALUE	NEW VALUE		
R511	150K	REMOVE	HORIZ/ HOLD RANGE
R513	56K	22K	
R514	5.6K	4.7K	
R562	JUMPER	1.5 OHM 2W	FILAMENT VOLTAGE
C403	273	REMOVE	STABILITY IMPROVES
C552	682 1.2KV	472 1.2KV	HV MONITOR CIRCUIT
C564	152 2KV	182 3KV	

Step-by-step conversion: **1.** Remove the cover. The top screws are behind snap-out covers, the bottom ones are behind stick-on plastic covers. **2.** Clip off R511 (150K) and C403 (27000 pF). This gives a wider horizontal and vertical range. They are located in the middle of the main deflection board. **3.** Add a 47K resistor across R513 (56K) and a 22K resistor across R514 (5.6K) underneath the middle of the main deflection board. This increases the horizontal frequency. **4.** Make a 25-pin to 15-pin adapter or replace the 25-pin connector with a 15-pin, as listed below.

SIGNAL	25 PIN (3179)	15 PIN (VGA)	WIRE COLOR
RED	15	1	YELLOW COAX
GREEN	16	2	BROWN COAX
BLUE	17	3	BLUE COAX
HORIZ.	21	13	BLUE
VERT.	22	14	PURPLE/PINK
GROUND	14	6-8,10,11	SHIELD BRAID

**5.** Turn on the monitor and adjust it as follows: A. Turn up the screen control until something appears. B. Turn the horizontal hold until the picture locks. C. Turn the vertical hold until it stops rolling. D. Adjust the vertical size and position as necessary. E. Turn up the power (VR 81) to 94 volts at connector B3. **6.** Optionally remove the horizontal width coil slug (located on the left side behind the horizontal output transistor). Then jumper across L554. This gives a wider picture. **7.** Optionally change the yoke capacitor (C560) from 1 uF to .82 to get a wider and more linear picture. **8.** Optionally change jumper 79 to a 1 ohm, 2 watt resistor. This slightly reduces the filament voltage. **9.** Use a 74LS86 circuit for sync phase correction. This can be built on a small circuit board and inserted between connector B1 and the deflection board. The five volts can be obtained from the video board. Basically this is an exclusive OR gate used as a selective inverter. The sync signal comes directly into one input, but through a 1K resistor into the second input, which also has a 5 uF capacitor to ground. This R-C network allows only the average voltage, which is the sync phase. On some monitors, the extra two gates are needed as inverters to get the correct sync phase.

This converted monitor gives EGA-like colors because its inputs are actually TTL. The analog output of some VGA cards may not be sufficient to drive TTL inputs. If this is the case, use three NE592s to buffer the video signals, or change the VGA card. Trident cards work very well. Some monitors can be modified to work better with analog inputs.

I no longer have a pin-out for the keyboard listed. The problem is that the scan codes are different and translation is difficult. The basic concept for converting keyboards is to match up the power and ground, then "easter egg" the clock and data lines. I have found few keyboards worth the trouble, as you can buy one for \$15.00.

For my book on converting monitors, and a whole lot more, send a check for \$15.00.

**Robert J. Davis**  
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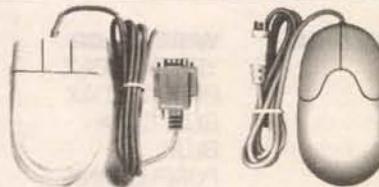
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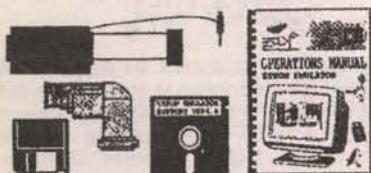
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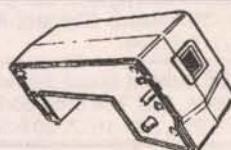
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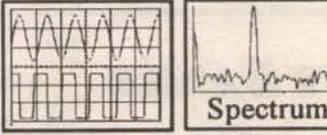
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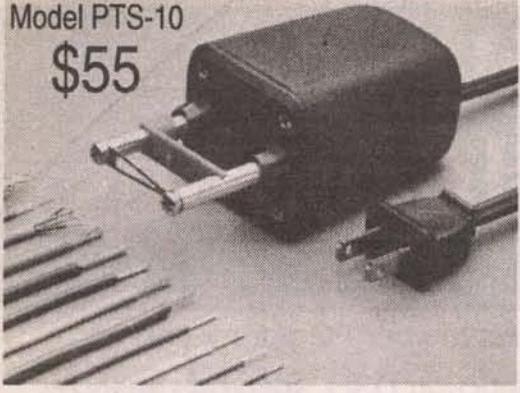
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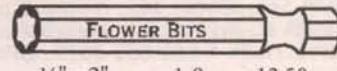
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# Stamp Applications:

The product — actually one of a family of products — is the TSL230 programmable light-to-frequency converter. The TSL230 measures light to the nearest gnat's whisker using an array of photodiodes, and outputs Stamp-friendly digital square waves. We'll look at two strategies for using it with the Stamps, one for the BS1 and another for the BS2.

## Look Into 'The Eye from TI' For Precision Light Readings

### TSL230 light-to-frequency chip plus beginner's race-timer project

Photodiodes are excellent light sensors — better in most applications than cadmium-sulfide photocells, phototransistors, photovoltaic cells, etc. What those other devices have going for them is that their outputs are easier to interface than the tiny variations in current through a photodiode. Nobody wants to fool around with the analog electronics required to use photodiodes.

Texas Instruments (TI) looked at this situation and, instead of saying, "ain't it a shame" said, "let's make a product!" The product — actually one of a family of products — is the TSL230 programmable light-to-frequency converter. The TSL230 measures light to the nearest gnat's whisker using an array of photodiodes, and outputs Stamp-friendly digital square waves. We'll look at two strategies for using it with the Stamps, one for the BS1 and another for the BS2.

In BASIC for Beginners, we'll lay the foundations of a fairly typical Stamp project: a three-lane race timer.

### The Eye from TI

Figure 1 is a block diagram of the TSL230 programmable light-to-frequency converter. The IC package (an eight-pin DIP) is transparent so that light shining on it reaches an array of photodiodes. An electronic sensitivity control connects part or all of this array to a current-to-frequency converter that I've labeled "analog magic." The frequency ranges from near 0 Hz in darkness to around 1.4 MHz in bright light.

The output is fed into a programmable divider that can pass the signal as-is, or divide it by 2, 10, or 100.

The TSL230 has a couple of especially microcontroller-friendly features: Its OE (output enable) pin lets you disconnect the output so that

it can share a data bus with other devices. And the sensitivity control may be used to power down the chip to reduce its current draw from 2 mA active to 10 µA idle.

Since the TSL230's output is basically a train of pulses, it's easy to measure with the Stamps using the Pulsin instruction available on the BS1 and BS2, or the new Count instruction on the BS2 only. Figure 2 shows the hook-up used in the example programs of Listings 1 and 2.

Using Pulsin, the Stamp measures the width of a single pulse. This provides a quick snapshot of the frequency. In order to get decent resolution out of a single pulse measurement, we want the pulse to be as long as possible without exceeding the max pulse width (655 ms for BS1 or 130 ms for BS2). To maximize pulse width, I set the output divider to 100, meaning that each output pulse represents 100 cycles from the light-to-frequency converter.

With the Count instruction, you can get high resolution by either ensuring that the frequency is close to the maximum that Count will handle (125 KHz), or by setting the instruction to count for a long period of time (up to 65 seconds).

Since bright light drives the light-to-frequency converter as high as 1.4 MHz, we have to set the programmable divider to ensure that the output to the BS2 never exceeds 125 KHz. The only setting that will do the trick is divide-by-100.

With that setting, the max output to the BS2 is 14 KHz. Count has a 16-bit range (65535 max), so it could be set to count as long as 4.6 seconds without overflowing. In the example program, I used a one-second count.

Both of the example programs display the effects of cycling the sensitivity settings through x1, x10, and x100. The sensitivity control is possibly the neatest feature of the chip. TI refers to it as an "electronic iris," since it works by controlling the surface area of the photodiode array used to drive the light-to-frequency converter. Want more sensitivity? Switch in all the photodiodes. Less? Switch in fewer photodiodes.

Controlling sensitivity can be important to a light-sensing application. For example, I found that in bright sunlight the x10 and x100 setting returned the same value. The light-to-frequency converter was saturated — driven as high as it would go regardless of further input. Only the x1 setting returned usable results in bright sunlight.

In normal room light, I saw the advantage of the higher sensitivity settings. I tried covering the TSL230 with a piece of transparent plastic cut from a plastic bag. At the x100 setting, the plastic

**Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips**

by Scott Edwards

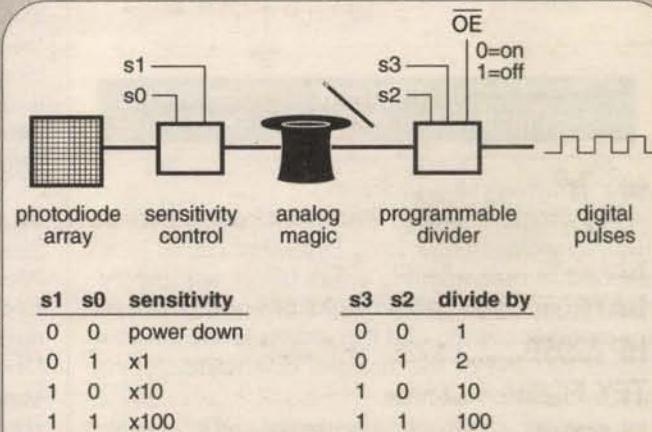


Figure 1. Simplified block diagram of the TSL230 light sensor.

made a large difference in the light measurement. At x1, it didn't make a difference at all.

Applications for the TSL230? TI uses a smart washing machine as an example. The TSL230 monitors the amount of light passing through the rinse water to determine when to end the cycle. A similar arrangement might keep tabs on the quality of water in an aquarium or beer in a vat. Photographic applications, like light metering, exposure control, color matching, densitometry, etc., seem obvious. Or how about an improved version of those heart-rate monitors that pass light through the skin? The frequency-modulated output of the TSL230 ought to be less vulnerable to noise than amplitude-modulated sensors.

### BASIC for Beginners

Programming is about problem solving, so this month, we'll conduct a brainstorming session aimed at finding a suitable solution to a typical

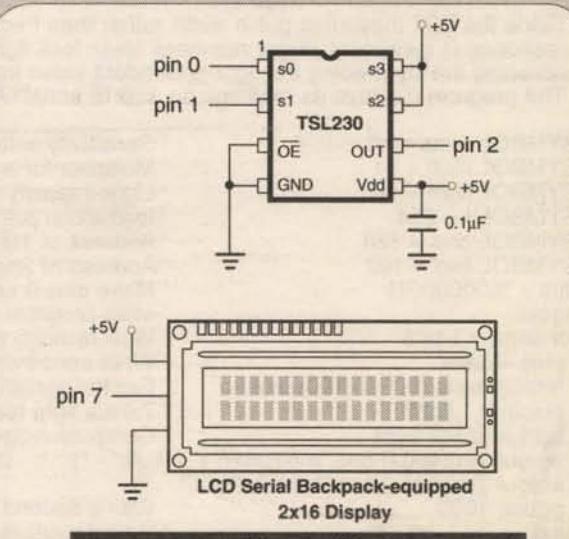
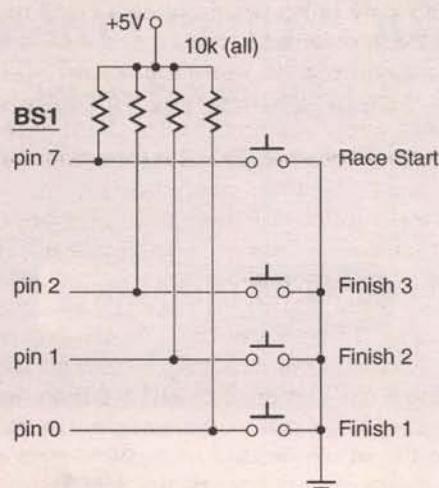


Figure 2  
Hook-up for Listings 1 and 2.

# Stamp Applications:



**Figure 3.**  
Arrangement of race-timer switches.

Stamp programming problem.

The problem is this: We want to use a BS1 as a three-lane race timer for a Pinewood Derby race. This kind of race involves small (6" or so) gravity-powered cars made from blocks of wood. The cars start simultaneously, and the winner is the car that reaches the end of the straight, downward-sloping track in the shortest time.

From an electronic standpoint, let's assume that we have four switches arranged as shown in Figure 3. The start switch pulses low when the cars leave the starting gate, and the three finish switches pulse low as their respective cars cross the finish line. The switches could be simple mechanical devices, or fancier light-beam electronic switches.

The most important function of our program will be to keep an accurate record of the time from start to finish for each of the cars. A secondary goal will be to have as much timing precision as possible, since a race may be won by just

milliseconds.

The first duty of our program will be to watch the start switch until it goes low, signaling the start of the race. We have two choices: to read the start pin directly, or to use the Button instruction, which offers such amenities as switch debouncing and autorepeat.

How to choose? Let's try to state the function of the start switch as specifically as possible. The contacts of the start switch will close at the instant the cars are released to start the race. The switch will bounce (flutter on/off for a few milliseconds) after initially closing, then stay closed for some indefinite amount of time. Once the cars are on their way, the switch may reopen after a while.

Hmm, switch bounce. Maybe we ought to go for the debouncing feature of Button. Or should we? After all, it's the initial switch closure that signals the start of the race, not what happens after that. Once the race starts, we can completely ignore the start switch. To put it into computerese, it's the high-to-low transition that matters. So Button is unnecessary; we can just watch the pin. A bit of initial coding and we have a test program:

```
SYMBOL starter = pin7
hold:
if starter = 1 then hold
debug "Start!", cr
end
```

As long as the start switch is open, the Stamp sees a 1 on pin 7 (which

## **Listing 1. BS1 Program to Demonstrate TSL230**

```
' Program: TSL230.BAS (Interface with TSL230 light sensor)
' This program demonstrates the light-to-frequency conversion
' capability of the TSL230 sensor from Texas Instruments.
' BS1 pins 0 and 1 control the sensitivity of the '230 through
' its "electronic aperture" feature. The higher the sensitivity,
' the higher the frequency output for a given light intensity,
' as shown below:
```

bit1	bit0	Sensitivity
0	0	sensor OFF
0	1	x1
1	0	x10
1	1	x100

```
' Since the BS1 measures pulse width rather than frequency, its
' response is reciprocal; larger numbers mean less light. The program
' reverses this by dividing the light-dependent value into 65535.
```

```
' The program displays its readings on a 2x16 serial LCD module.
```

```
SYMBOL sens = b2
SYMBOL mult = b1
SYMBOL light = w2
SYMBOL l = 254
SYMBOL one = 128
SYMBOL two = 192
dirs = %00000011
again:
for sens = 1 to 3
pins = sens
lookup sens,(0,1,10,100),mult
pulsin 2,1,light
light = 65535/light
serout 7,n2400,[l,one,"multiplier: x",#mult," "] ' Display.
serout 7,n2400,[l,two,"light: ",#light," "] ' Display.
pause 1000
next
goto again
```

```
' Sensitivity setting.
' Multiplier for a given sensitivity.
' Light-intensity reading.
' Instruction prefix for LCD.
' Address of 1st LCD line.
' Address of 2nd LCD line.
' Make pins 0 and 1 outputs.
' Main program loop.
' Walk through sensitivity settings.
' Write sensitivity setting to pins.
' Get the sensitivity multiplier.
' Take a light reading.
' Compute reciprocal.
' Wait a second between readings.
' Next sensitivity.
' Repeat forever.
```

## Sources

For more information on the BASIC Stamp, contact:

**Parallax, Inc.**

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phone (916) 624-8333

Internet <http://www.parallaxinc.com>

The TSL230 is available from:

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we have renamed "starter"). So the program keeps executing the line after hold — over and over. When the switch closes, starter is equal to 0, so the if...then condition is no longer true. The program drops down to the next line and prints the "Start!" message on the debug screen.

Now comes the harder part — keeping track of time for each of the racers until they cross the finish line. The Stamp doesn't have a timer function, so 'keeping time' really means adding 1 to a counter in a loop that ends when the race is over. For instance, if we had only one car to keep track of, we could use a variation of the

## **Listing 2. BS2 Program to Demonstrate TSL230**

```
' Program: TSL230.BS2 (Interface with TSL230 light sensor)
' This program demonstrates the light-to-frequency conversion
' capability of the TSL230 sensor from Texas Instruments.
' BS1 pins 0 and 1 control the sensitivity of the '230 through
' its "electronic aperture" feature. The higher the sensitivity,
' the higher the frequency output for a given light intensity,
' as shown below:
```

bit1	bit0	Sensitivity
0	0	sensor OFF
0	1	x1
1	0	x10
1	1	x100

```
' This BS2 program uses the COUNT instruction to count the number
' of TSL230 output cycles over a period of 1 second. This approach
' trades a relatively long measurement period for excellent
' resolution and accuracy. For a quick-and-dirty measurement,
' the PULSIN approach used with the BS1 could be employed instead.
' The program displays its readings on a 2x16 serial LCD module.
```

sens	var byte	' Sensitivity setting.
mult	var byte	' Multiplier for a given sensitivity.
light	var word	' Light-intensity reading.
l	con 254	' Instruction prefix for LCD.
one	con 128	' Address of 1st LCD line.
two	con 192	' Address of 2nd LCD line.
n2400	con \$418d	' Serial constant for 2400 bps

dirs = %00000011	' Make pins 0 and 1 outputs.
again:	' Main program loop.
for sens = 1 to 3	' Walk through sensitivity settings.
OUTS = sens	' Write sensitivity setting to pins.
lookup sens,[0,1,10,100],mult	' Get the sensitivity multiplier.
count 2,1000,light	' Count pulses for 1 second.
serout 7,n2400,[l,one,"multiplier: x",#mult," "]	' Display.
serout 7,n2400,[l,two,"light: ",#light," "]	' Next sensitivity.
next	' Repeat forever.
goto again	

# Stamp Applications:

hold loop above:

```

SYMBOL finish = pin0
SYMBOL time = w2
... (hold loop here) ...
timing:
if finish = 0 then raceOver
time = time + 1
goto timing
raceOver:
debug "Finish time = ", #time, cr
end

```

While this approach would be fine for one lane, it wouldn't work at all for three lanes. The race ends only when all three cars have finished, and a finish switch only pulses briefly when its car crosses the finish line. Thinking about adding a second lane to that program, you might be tempted to write:

```

if finish1 = 0 then raceOver
if finish2 = 0 then raceOver

```

Then all timing would stop when either car crossed the finish line. We want race times for all

cars, and for the race to finish only when all cars are done. Another thought might be:

```

if finish1 = 0 and finish2 = 0 ...
... then raceOver

```

No good. This code would only work if car 1 and car 2 finished simultaneously.

The point is that there's really no way to patch up the one-lane approach to work for three lanes. Something critical is missing, and we have to figure out what it is before we can make a working program.

Why did I show you this blind alley? I wanted to talk about courage. That's right, courage; it takes guts to throw away an idea that initially seems promising.

The cowardly thing to do would be to attempt to save that first-draft code by adding more and more instructions to counter each of its deficiencies.

We're brave and bold enough to say "phooey" to a bad idea. Let's start over with another run at the problem in light of that false start.

The primary problem with the one-lane code is that it can't deal with the fact that the finish

switches only pulse when the cars cross the finish line. If these switches came on and stayed on, that code would be a lot more viable. Ah, the snake rears its ugly head. Faced with difficulty, you begin to think about messing with the hardware to salvage bad software. Resist temptation; hardware mods are a last resort. Keep thinking.

Okay, suppose we store the status of each car as something like "racing" and "finished." Then we have a clear-cut condition for keeping time, as in 'racing1 = 1 then time1 = time1+1.' (Assuming that 'racing1' is the status of car1, where 1=in-the-race and 0=finished.) We also have a clear condition for stopping a car's timer; 'if finish1 = 0 then racing1 = 0.' And — hallelujah — we have a condition for ending the whole race; 'if racing1 = 0 and racing2 = 0 and racing3 = 0 then all\_finished.'

It appears that our racing timer is now on the right track.

Next month, we'll prototype the racing timer application and look at ways to streamline the code. We'll see how bit variables can be used as flags, and how to convert If...Then instructions into compact Boolean logic. I think you will be surprised and pleased to see how simple the final code is. NV

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### STORAGE

TEK 7834 400 MHz Storage Oscilloscope, w/7A24, 7A26, 7B80, 7B85 .....	\$1,250.00
TEK SC503 10 MHz Dual Trace Storage Oscilloscope, TM500 series .....	\$700.00
TEK R7903/7S11/T11/S-4 12 GHz Sampling Oscilloscope System .....	\$1,750.00
TEK S-4 14 GHz Sampling Head .....	\$300.00
TEK 1101 Accessory Power Supply, for FET probes .....	\$250.00
TEK P6046 100 MHz Differential Probe .....	\$750.00

### PROBES

TEK P6101A 34 MHz 1X Modular Probe, 2m length "NEW" .....	\$25.00
TEK P6108A 100 MHz 10X Modular Probe, 2m length "NEW" .....	\$50.00
TEK P6201 900 MHz 1X/10X/100X FET Probe .....	\$450.00
TEK P6202A 500 MHz 10X FET Probe .....	\$300.00
TEK P6203 10X 1 GHz Active Probe, for 11000 series .....	\$450.00
TEK P6701-opt.02 O/E Converter, 450-1050 nm/0-1 mW: DC-700 MHz, ST conn. ....	\$675.00

### CALIBRATION

TEK 067-0587-01 Signal Standardizer .....	\$300.00
Calibration Plug-in, 7000 series .....	
TEK CG5001-opt.01/TM5006 Programmable Oscilloscope Calibrator, with power module .....	\$7,000.00
TEK CG551AP/TM506A Oscilloscope Calibrator, with pulse head & power module .....	\$3,500.00

## WAVEFORM GENERATORS

### FUNCTION

HP 3310A 5 MHz Function Generator .....	\$325.00
HP 3310B 5 MHz Function Generator, monochrome & var.phase trigger .....	\$425.00
HP 3312A 13 MHz Function Generator, sweep, AM, FM .....	\$850.00
TEK DD501 Digital Delay & Burst Gen., for function & pulse gen's .....	\$375.00
TEK FG501 1 MHz Function Generator, TM500 series .....	\$250.00
TEK FG502 11 MHz Function Generator, TM500 series .....	\$325.00
TEK FG503 3 MHz Function Generator, TM500 series .....	\$275.00
TEK FG504 40 MHz Function Generator, TM500 series .....	\$875.00
TEK RG501 Ramp Generator, TM500 series .....	\$225.00
WAVETEK 23 12 MHz Synthesized Function Generator .....	\$1,100.00

### PULSE

HP 214B 10 MHz Pulse Generator, 50 V/50 Ohms, auto duty cycle .....	\$1,650.00
HP 214B-001 10 MHz Pulse Generator, 50 V/50 ohms, counted burst opt .....	\$2,000.00
HP 8005B 20 MHz Dual Output Pulse Generator .....	\$450.00
HP 8007B 100 MHz Pulse Generator .....	\$650.00
HP 8013B 50 MHz Dual Output Pulse Generator, 3.5 nS fixed Tr .....	\$600.00
HP 8015A 50 MHz Dual Output Pulse Generator .....	\$700.00
HP 8080/A81/A82/A83A 300 MHz Word Generator .....	\$600.00
HP 8080/A81/A92/A93A 1 GHz Single Channel Pulse Generator .....	\$950.00
HP 8080/A91/A93A 1 GHz Clock Generator .....	\$600.00
HP 8082A 250 MHz Dual Output Pulse Generator .....	\$1,400.00
PHILIPS PM5785B 125 MHz Dual Output Pulse Generator, burst mode, 1 nS Tr .....	\$875.00
TEK PG501 50 MHz Pulse Generator, TM500 series .....	\$250.00
TEK PG502 250 MHz Pulse Generator, Tr<1nS, TM500 series .....	\$700.00
WAVETEK 801 50 MHz Pulse Generator .....	\$350.00

## PROGRAMMABLE

HP 3314A Multi-Waveform Generator, 0.001 Hz-19.99 MHz, GPIB .....	\$3,500.00
HP 3325A-002 Synth./Function Gen., 1 uHz-21 MHz, 40V out 1 uHz-1 MHz .....	\$2,400.00
HP 8160A 50 MHz Programmable Pulse Generator, GPIB .....	\$2,500.00
HP 8165A-002.003 Proc. Signal Source, 1 mHz-50 MHz, log sweep, rear out .....	\$2,000.00
TEK AWG5102 Arb.Waveform Gen., 20 MS/s,12 bits,50ppm synthesis <1MHz .....	\$1,400.00
TEK AWG5105 Arbitrary Waveform Generator, 50 MS/s, 12 bits .....	\$1,700.00
TEK AWG5105-opt.02 Arbitrary Waveform Generator, dual channel option .....	\$2,200.00
TEK FG5010 Programmable 20 MHz Function Generator, TM5000 series .....	\$1,200.00
TEK PFG5505 Programmable 12 MHz Pulse/Function Generator .....	\$900.00
WAVETEK 288 20 MHz Synthesized Function Generator, GPIB .....	\$1,500.00

GR 1433-X 6-Decade Resistor, to 111,111.0 ohms, 0.1 ohm res. ....	\$550.00
GR 1434-G 7-Decade Resistor, 0-1,111,111.0 ohms, 0.1 ohm res. ....	\$400.00
HP 16380A Standard Air Capacitor Set; 1, 10, 100, 1000 pF .....	\$1,675.00
VALHALLA 2724A Programmable Resistance Standard, 0-11 Gigohms, GPIB .....	\$1,675.00

## HI & LO RESISTANCE

HP 4329A High Resistance Meter, 5E5-2E16 Ohms, 10-1000 V test .....	\$1,350.00
VALHALLA 4150-ATC 4-1/2 digit Ohmmeter, 20 millionohms-2 kilohms, 4-wire .....	\$1,000.00

## CURVE TRACERS

TEK 576 Curve Tracer, with standard test fixture .....	\$2,350.00
TEK 577D1/177 Storage Curve Tracer, with standard test fixture .....	\$2,250.00
TEK 7CT1N Curve Tracer, to 0.5W, 7000 series .....	\$400.00
T.D.R.	
TEK 1503-opt.04 Time Domain Reflectometer, 0-50,000 feet,chart recorder .....	\$1,900.00

## POWER SUPPLIES

### SINGLE OUTPUT

HP 6201B 20 V at 1.5A CV/CC Power Supply .....	\$200.00
HP 6206 Dual Range 0-60 V 0.5 A /0-30 V 1 A CV/CL Supply .....	\$250.00
HP 6207B 160 V at 200 mA CV/CC Power Supply .....	\$300.00
HP 6260B-027 20 V at 100 mA CV/CC Power Supply .....	\$675.00
HP 6261B-027 20 V at 50 A CV/CC Power Supply .....	\$675.00

HP 6266B 40 V at 5 A CV/CC Power Supply .....	\$400.00
HP 6267B 40 V at 10 A CV/CC Power Supply .....	\$550.00
HP 6268B-027 40 V at 30 A CV/CC Power Supply .....	\$850.00
HP 6299A 100 V at 750 mA CV/CC Power Supply .....	\$250.00
HP 6384A 4.0-5.5 V at 8 A CV/CL Power Supply .....	\$175.00

HP 6434B 40 V at 25 A CV/CC Power Supply .....	\$800.00
HP 6448B 600 V at 1.5 A CV/CC Power Supply .....	\$850.00
HP/HARRISON 6443B 120 V at 2.5 A CV/CC Power Supply .....	\$400.00
LAMBDA LES-EE-03-OV 36 V at 14.5 A CV/CC Power Supply, LED metered .....	\$500.00

SORENSEN DCR 110-45T 110 V at 45 A CV/CC Power Supply .....	\$2,200.00
SORENSEN DCR 150-6B 150 V at 6 A CV/CC Power Supply .....	\$650.00
SORENSEN DCR 300-6B 300 V at 6 A CV/CC Power Supply .....	\$950.00
SORENSEN DCR 300-8A 300 V at 8 A CV/CC Power Supply .....	\$950.00
Power Supply, 208/230 VAC line .....	

SORENSEN SRL 20-12 20 V at 12 A CV/CC Power Supply, low noise .....	\$550.00
SORENSEN SRL 60-8 60 V at 8 A CV/CC Power Supply, low noise .....	\$950.00
TEK PS501-1 Power Supply, 0-20 V, 2 mV res., 400 mA, TM500 series .....	\$175.00
MULTIPLE OUTPUT	

HP 6227B Dual 25 V at 2 A CV/CC Power Supply, tracking .....	\$550.00



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**90 DAY WARRANTY PARTS AND LABOR • 10 DAY INSPECTION**  
**TEST EQUIPMENT WANTED CALL OR FAX LIST • OPEN ACCOUNTS**



HP 5340A-005,011 23 GHz Frequency Counter, HPIB	\$2,000.00
HP 5342A 18 GHz Frequency Counter	\$2,400.00
HP 5342A-003,011 18 GHz Freq.Counter, +22 dBm,-20 dBm dynamic range,HPIB	\$2,750.00
HP 5342A-01,04,05,11 24 GHz Frequency Counter, OCXO, DAC, and HPIB	\$3,900.00
HP 5345A/5355A/5356B 26.5 GHz CW/Pulse Frequency Counter	\$4,000.00
HP 5382A 225 MHz Frequency Counter	\$200.00
<b>STANDARDS</b>	
HP 105A Quartz Oscillator, 0.1/1.0/5.0 MHz	\$750.00
HP 5087A-031 Distribution Amp., 0.1/1.0/5.0 MHz x 4 channels each	\$1,250.00

### AUDIO & BASEBAND

#### SPECTRUM ANALYZERS

HP 8556A LF Section, 20 Hz-300 kHz ..... \$500.00

#### DISTORTION ANALYZERS

HP 334A Distortion Analyzer, 5 Hz-600 kHz, -60 dB, auto nulling ..... \$550.00

HP 339A Distortion Analyzer, built-in low distortion osc. ..... \$2,400.00

TEK AA5001 Distortion Analyzer ..... \$2,000.00

TEK DA4084 Programmable  
Distortion Analyzer, 0.0025% THD, w/frame

#### RMS VOLTMETERS

FLUKE 8920A True RMS Voltmeter, ..... \$700.00

180 uV-700 V, 10 Hz-20 MHz

FLUKE 8921A True RMS Voltmeter, 180 uV-700 V, 2 Hz-2 MHz ..... \$700.00

HP 3400A RMS Voltmeter, 10 Hz-10 MHz ..... \$250.00

#### OSCILLATORS

FLUKE 6011A Synthesized Generator, ..... \$1,200.00

10 Hz-11 MHz, 10 Hz res.

HP 204D Oscillator, 5 Hz-1.2 MHz, 5 VRMS, 80 dB step attenuator ..... \$200.00

HP 209A Sine/Square Wave Generator, 4 Hz-2 MHz, 5 VRMS max. .... \$225.00

HP 239A Low Distortion Oscillator, 10 Hz-100 kHz ..... \$450.00

HP 652A Test Oscillator, 10 Hz-10 MHz ..... \$300.00

ROCKLAND 5100 Synthesizer, 1 mHz-1.999999999 MHz ..... \$350.00

TEK SG502 Sine/Square Osc. ..... \$350.00

5 Hz-500 kHz, 70 dB step atten., TM500

TEK SG505-opt.01 Low Distortion Oscillator, ..... \$1,000.00

10 Hz-100 kHz, intermod.opt.

#### MISCELLANEOUS

HP 3575A-001 Phase-Gain Meter, 1 Hz-13 MHz, dual display ..... \$900.00

HP 4437A Step Attenuator, 0-119.9 dB, ..... \$200.00

DC-1 MHz, 600 ohms unbal

KROHN-HITE 3103 High/Low Pass Filter, ..... \$500.00

10 Hz-3 MHz, 24 dB/octave

KROHN-HITE 3202 Dual High-Pass/Low-Pass  
Filter, 20 Hz-2 MHz, 24 dB/oct

KROHN-HITE 3342 Dual HP/LP Filter, ..... \$1,100.00

0.001 Hz-99.9 kHz, 48 dB/octave

KROHN-HITE 3750 LP/HP/BP/BR Filter, ..... \$700.00

0.02 Hz-20 kHz, 6/12/18/24 dB/oct.

ROCKLAND 852 Dual Highpass/Lowpass Filter, 0.1 Hz-111 kHz ..... \$1,000.00

TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series ..... \$575.00

### RF & MICROWAVE

#### SPECTRUM ANALYZERS

HP 11517A/18A/19A/20A Mixer, ..... \$675.00

12.4-40 GHz, w/adapters, for 8555A, 8565A, etc.

HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz ..... \$1,100.00

HP 11970Q WR22 Harmonic Mixer, 33-50 GHz ..... \$1,400.00

HP 11970U WR19 Harmonic Mixer, 40-60 GHz ..... \$1,400.00

HP 11971A WR28 Harmonic Mixer, 26.5-40.0 GHz, for 8569B ..... \$1,100.00

HP 11971K WR42 Harmonic Mixer, 18.0-26.5 GHz, for 8569B ..... \$1,100.00

HP 5371A Modulation Domain Analyzer, 125 mHz-500 MHz ..... \$4,000.00

HP 8406A Comb Generator, 1/10/100 MHz increments, to 5 GHz ..... \$450.00

HP 8444A-059 Tracking Generator, ..... \$1,500.00

0.5-1500 MHz, for 8554, 8568, etc.

HP 8445B Preselector, 1.8-18.0 GHz, for HP 8555A. ..... \$800.00

HP 8559A/853A Spectrum Analyzer, ..... \$5,500.00

10 MHz-21 GHz, 1 kHz res., w/display

TEK 7L13/7613 Spectrum Analyzer, ..... \$2,250.00

1 kHz-1.8 GHz, 30 Hz min.res., w/frame

TEK TR502 Tracking Generator, 0.1-1800 MHz, for 7L12/13/14 ..... \$1,250.00

TEK TR503 Tracking Generator, 0.1-1800 MHz, for 492/4/5/6 ..... \$1,375.00

#### NETWORK ANALYZERS

HP 11590A Bias Network, 1.0-12.4 GHz, N(II) ..... \$375.00

HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 ..... \$450.00

HP 11665B Modulator, 0.15-18.0 GHz, for use with 8755/6/7 ..... \$375.00

HP 11666A Reflectometer Bridge, 0.04-18 GHz, for 8755/8756 ..... \$1,200.00

HP 8407A/8412A/8601A Network Analyzer, ..... \$1,250.00

100 kHz-110 MHz, with sweep generator

HP 85050D APC7 Calibration Kit, for 8510 series ..... \$1,100.00

HP 85050A-005/8503A Network An., ..... \$5,000.00

0.5-1300 MHz, w/S-Parameter & phase lock

HP 8755C/(3)11664A/182T Scalar ..... \$1,750.00

Network An, w/3 detectors, 10 MHz-18 GHz & frame

HP 8756A/(3)11664A Scalar Network ..... \$3,750.00

Analyzer, w/(3) detectors, 0.01-18 GHz

Narda 7000A/7202/7206 Microwave Multimeter ..... \$1,950.00

System: scalar analysis 0.1-18 GHz

WAVETEK 1038D14A/H12/V13x2 ..... \$2,200.00

Scalar Network An,w/(3)15882 WR28 detectors,26.5-40 GHz

WILTRON 640/G50/E(2)/7B50(2) ..... \$1,675.00

Network An., w/1-1500 MHz source, (2) log amp, (2) det.

#### SIGNAL GENERATORS

FLUKE 6060A/AN Synthesized Signal Gen., ..... \$2,000.00

10 kHz-520 MHz, 10 Hz res, GPIB

GIGATRONICS 600/10-18, opt.06 Synthesized Source, 10-18 GHz, 1 MHz res., OCXO, GPIB	\$3,000.00	FXR/MICROLAB S3-02N Triple Stub Tuner, ..... \$90.00
GIGATRONICS 875/50 Levelled Multiplier, x4, 50.0-75.0 GHz output, -3 dBm	\$3,500.00	200-1000 MHz, 100 Watts max., N(m/l)
GIGATRONICS 875/86 Levelled Multiplier, 26.5-40.0 & 50.0-75.0 GHz outputs	\$7,000.00	GR 874-LTL Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz
GIGATRONICS 910/12-18,opt6,14,16 Synthesized Source/Sweeper, 12-18 GHz, 1 Hz res., OCXO	\$3,500.00	GR 900-Q GR900 14mm Interseries Adapters
HP 85100V Frequency Multipl., 10-15 GHz in / 50-75 GHz out >0 dBm	\$4,250.00	HP 11691D Directional Coupler, 22 dB, 2-18 GHz
HP 8616A Signal Generator, 1.8-4.5 GHz	\$450.00	HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz
HP 8640B-001,002,003 Signal Gen., 0.5-1024 MHz, AM, FM, var. audio osc.	\$2,750.00	HP 775D Dual Directional Coupler, 20 dB, 450-940 MHz
HP 8647A-1E5 Synth. Signal Gen., 0.25-1000 MHz, display res. 10 Hz	\$3,750.00	HP 776D Dual Directional Coupler, 20 dB, 940-1900 MHz
HP 8654A Signal Generator, 10-520 MHz, calibrated AM & uncal. FM	\$625.00	HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz
HP 8656A Signal Generator, 0.1-990 MHz, 100 Hz res, AM, FM, HPIB	\$2,900.00	HP 778D Dual Dir.Coupler, 20 dB, 100-2000 MHz, N(m/l/l/f)
HP 8660C/86602B/86632A Synthesized Signal Gen., 1-1300 MHz, 1 Hz res., AM, FM	\$2,750.00	HP 778D-011 Dual Dir.Coupler, 20 dB, 1000-2000 MHz, APC7/N(l/f/f)
HP 8660D/86630A/86632B Synthesized Signal Generator, 1-2600 MHz	\$7,000.00	HP 8472A Crystal Detector, 10 MHz-18 GHz, neg. pol., SMA(m)
WAVETEK 907 Signal Generator, 7.0-11.0 GHz, 0 dBm levelled	\$1,000.00	HP 8498A-030 30 dB Attenuator, 25 Watts, DC-18 GHz, N(m/l)
<b>SWEEP GENERATORS</b>		HP K382A WR42 Precision Rotary Vane Atten., 0-50 dB, 18-26.5 GHz
HP 8350A/86290B-H08 Programmable Sweep System, 2.0-22.0 GHz, +4 dBm lvd'	\$5,500.00	HP K422A WR42 Flat Broadband Defector, 18.0-26.5 GHz
HP 8600A Digital Marker, for HP 8601A	\$400.00	HP K532A WR42 Frequency Meter, 18.0-26.5 GHz
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled	\$500.00	HP K752 A/C/D WR42 Directional Couplers, 3/10/20 dB, 18.0-26.5 GHz
HP 8620C Sweep Oscillator Frame	\$550.00	HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz
HP 8620C-011 Sweep Oscillator Frame, HPIB programmable	\$675.00	HP R375A WR28 Variable Attenuator, 0-20 dB, 26.5-40 GHz
HP 86220A RF Plug-in, 10-1300 MHz, +10 dBm levelled	\$800.00	HP R422A WR28 Flat Broadband Defector, 26.5-40 GHz
HP 86222A RF Plug-In, 10-2400 MHz, +13 dBm levelled	\$1,375.00	HP R532A WR28 Frequency Meter, 26.5-40.0 GHz
HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled	\$675.00	HP R914B WR28 Moving Load, 26.5-40 GHz
HP 86240A RF Plug-in, 2.0-8.4 GHz, +16 dBm levelled	\$1,000.00	HP X913A WR90 High Power Load, 50 Watts, 8.2-12.4 GHz
HP 86240A-002 RF Plug-in, 2.0-8.4 GHz, +14 dBm lvd., 70 dB step att.	\$1,200.00	HUGHES 4511H-2000 WR19 Isolator, 25 dB, 26.5-40 GHz
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled	\$500.00	HUGHES 4511H-1000 WR19 Isolator, 25 dB, 40-60 GHz
HP 86242D-004,008 RF Plug-In, 5.9-9.0 GHz, +10 dBm levelled	\$500.00	HUGHES 4552H-2000 WR28 Manual 4-Position Switch
HP 86245A RF Plug-in, 5.9-12.4 GHz, +16 dBm levelled	\$1,100.00	HUGHES 47316H-1111 WR10 Tunable Detector, 75-110 GHz, positive polarity
HP 86250D RF Plug-in, 8.0-12.4 GHz, +10 dBm levelled	\$675.00	HUGHES 47974H-1000 WR15 SPST
HP 86260A RF Plug-in, 12.0-18.0 GHz, +10 dBm unlevelled	\$800.00	PIN Switch, 250 MHz speed, 60-62 GHz response
HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm unlevelled	\$800.00	M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz
HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled	\$1,750.00	NARDI 25171 Level Set Attenuator, 0-17 dB, 2-8 GHz, SMA(f)
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled	\$2,250.00	NARDI 26298 20 dB Attenuator, 150 Watts, DC-1 GHz, N(l/f)
HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled	\$2,500.00	NARDI 3030-SERIES Directional Couplers
WAVETEK 962 Sweep Generator, 1.0-4.0 GHz, markers, +12 dBm univid.	\$2,000.00	NARDI 3080-SERIES Precision High Directivity Couplers
<b>POWER METERS</b>		NARDI 369BNF High Power Termination, 175 Watts, 0.7-18 GHz, N(l/f)
ANRITSU MP-81B/ML-83A Power Meter, ..... \$2,500.00		NARDI 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz
75-110 GHz (WR10), -20 to +20 dBm		NARDI 3753B Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz
ANRITSU MP-82B/ML-83A Power Meter, ..... \$3,250.00		NARDI 4000-SERIES SMA Miniature Directional Couplers
90-140 GHz (WR8 pin flange), -20 to +20 dBm		NARDI 4203-6 Directional Coupler, 6 dB, 2-18 GHz, SMA(l/f/l)
BOONTON 4200/4G Power Meter, ..... \$1,500.00		NARDI 4246B-10 Directional Coupler, 10 dB, 6-18 GHz, SMA(f)
1 MHz-26.5 GHz, -50 to +10 dBm		NARDI 4317-2 Power Divider, 18.0-26.5 GHz, 3.5mm
BOONTON 42B/41-4E Analog Power Meter, with 1 MHz-18 GHz sensor	\$500.00	NARDI 4799 Level Set Attenuator, 0-15 dB, 4-18 GHz, SMA(f)
BOONTON 42B/42A-S3 Analog Power Meter, with 1 MHz-8.4 GHz N(l/f) sensor	\$375.00	NARDI 5070-SERIES Precision Reflectometer Couplers
GENERAL MICROWAVE 476/4240A Power Meter & Sensor, 0.01-18 GHz, -35 to +10 dBm	\$375.00	NARDI 562

# Events

NOVEMBER 1996

NOVEMBER 1

**MA - FEEDING HILLS** - Auction, Feeding Hills Congregational Church. Steve 413-596-8216

NOVEMBER 2

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

**CA - VENTURA** - Computer Show. Ventura Fairgrounds. MarketPro 415-456-6730

**CT - WATERFORD** - Ham Radio Auction. Senior Citizens Center. Municipal Complex. KA1BB 203-739-8016

**DE - NEWARK** - Computer Show. University of Delaware. MarketPro 301-984-0880 xt15

**FL - SORRENTO** - Hamfest & Electronic Expo. East Lake Chamber of Commerce. Tony 352-360-1380

**IL - GODFREY** - ARRL Hamfest. Lewis & Clark RC. Brent Ufer 618-498-4865

**MA - FALL RIVER** - Computer Show. White's of Westport. Northern Computer Shows. 508-744-8440

**MD - UPPER MARLBORO** - Computer Show. The Show Place Arena. MarketPro 301-984-0880 xt15

**MI - LAINGSBURG** - Super Computer Sales. Laingsburg HS. Computers & You 313-283-1754

**NY - HEMPSTEAD** - Computer Show. Hofstra University, Field House. 908-297-2526

**NY - MIDDLETOWN** - Computer Show. Orange County Comm. College. MarketPro 201-825-2229

**OK - ENID** - Hamfest. Hoover Bldg., Garfield Co. Fairgrounds. Fred N5QXL, Jeff EnidARC@AOL.COM

**WI - MILWAUKEE** - Hamfest. Milwaukee Repeater Club. Burt 414-328-0535

NOVEMBER 2-3

**CA - SACRAMENTO** - Computer Show. Cal Expo. MarketPro. 415-456-6730

**FL - ORLANDO** - Computer Show. Central FL Fairgrounds. MarketPro 301-984-0880 xt15

**GA - LAWRENCEVILLE** - ARRL Hamfest. Alford Memorial RC. Randy Bassett 770-410-3989

**KY - LOUISVILLE** - Computer Show. Hurstbourne Hotel. MarketPro 301-984-0880 xt15

**OH - CINCINNATI** - Computer Fair. Cincinnati Gardens. Mark Hanslip 513-263-3378

**TN - NASHVILLE** - Computer Fair. TN State Fairgrounds. Trade Show Productions 513-263-3378

**TX - ODESSA** - Hamfest. Ector Co. Coliseum Exhibit Bldg. C. West Texas ARC. Robert 915-335-7980

NOVEMBER 3

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857

**MI - MADISON HEIGHTS** - Super Computer Sales. U.F. & C.W. Hall. Computers & You 313-283-1754

**MI - MIDLAND** - Computer Show. Holiday Inn. Five Star Productions. 810-230-0988

**NH - SALEM** - Computer Show. Rockingham Park Race Track. Northern Computer 508-744-8440

**NJ - PARSIPPANY** - Computer Show. Parsippany Hilton. MarketPro 201-825-2229

**OH - CANTON** - ARRL Hamfest. Massillon ARC. Jack Hale 216-477-8261

**PA - TREVOSSE** - Photographic Show. Radisson Hotel. OMM Productions 610-527-5903

**PA - READING** - Computer Show. Sheraton Berkshire. MarketPro 301-984-0880 xt15

**VA - MANASSAS** - Computer Show. Manassas Fairgrounds. MarketPro 301-984-0880 xt15

NOVEMBER 9

**AL - MONTGOMERY** - Hamfest & Computer Show. Garrett Coliseum, South Alabama State Fairgrounds. Montgomery ARC. Phil 334-272-7980

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**CA - FRESNO** - Computer Show. Fresno Fairgrounds. MarketPro 415-456-6730

**FL - TITUSVILLE** - ARRL Hamfest. Titusville ARC. Clyde Lee 407-267-9375

**IL - CHICAGO** - Computer Faire. Evanston Library. Hal Shanafield 847-864-8644

**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 317-299-8827

**IN - INDIANAPOLIS** - Computer Show. State Fairgrounds. MarketPro 301-984-0880 xt15

**LA - WEST MONROE** - Hamfest. Conv. Center. Becky Ketchell 318-343-3530

**MA - STURBRIDGE** - Computer Show. Sturbridge Host Hotel. Northern Computer 508-744-8440

**MD - FREDERICK** - Computer Show. Frederick Fairgrounds. MarketPro 301-984-0880 xt15

**MI - KALAMAZOO** - Super Computer Sales. Co. Fairground. Computers & You 313-283-1754

**PA - HERSHEY** - Hamfest. Hershey Armory. Harold Baer 717-566-8895

**PA - LEBANON** - Computer Show. Valley Expo

# CALENDAR

The Events Calendar is a free service limited to electronic events such as computer shows, hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days prior to the event. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:

**Nuts & Volts Magazine**

**Events Calendar**

430 Princeland Court

Corona, CA 91719

**Phone** 909-371-8497

**Fax** 909-371-3052

**E-mail** events@nutsvolts.com

Center (West wing) MarketPro 301-984-0880 xt15

**RI - WEST WARWICK** - Computer Show. Civic Center. MarketPro 201-825-2229

**SC - MYRTLE BEACH** - Radio/Computer Show. High School. Dave Berry 803-248-9401

**WA - FERNDALE** - Hamfest. Mt. Baker ARC. Al Norton. 360-354-4622

NOVEMBER 9-10

**GA - DALTON** - Computer Show. NW GA Trade & Conv. Center. ComputerShow 770-907-6225

**NJ - EDISON** - Computer Show. NJ Convention & Expo Center, Raritan Center Expo Hall. 908-297-2526

NOVEMBER 10

**CA - SAN DIEGO** - Computer Show. Scottish Rite Center. MarketPro 415-456-6730

**CA - VALLEJO** - Computer Show. Solano Co. Fairgrounds. MarketPro 415-456-6730

**CT - BRANFORD** - SCARA Flea. Branford Intermediate School. 203-483-0856

**FL - WEST PALM BEACH** - Computer Show. Palm Beach Airport Hilton. Narisaam 770-663-0983

**IL - MACOMB** - Hamfest. Lamoine Emergency ARC. Kathy Page 309-426-2723

**IN - MUNCIE** - Computer Show. Horizon Convention Center. MarketPro 301-984-0880 xt15

**MA - FITCHBURG** - Computer Show. Royal Plaza Trade Center. MarketPro 201-825-2229

**MD - NEW CARROLLTON** - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880 xt15

**MI - GRAND RAPIDS** - Super Computer Sales. Crowne Plaza. Computers & You 313-283-1754

**NH - PORTSMOUTH** - Computer Show. Frank Jones Center. Northern Computer 508-744-8440

**PA - DICKSON CITY** - Computer Show. Genetti Manor. MarketPro 301-984-0880 xt15

**PA - WASHINGTON** - Hamfest & Computer Fair. Chartiers-Houston HS. Ted 412-222-6473

NOVEMBER 11

**CA - MODESTO** - Computer Show. Centre Plaza at Red Lion. MarketPro 415-456-6730

NOVEMBER 15-16-17

**IA - DES MOINES** - Computer Sale>Show. State Fairgrounds. Blue Star Productions. 612-788-1901

NOVEMBER 16

**CA - BAKERSFIELD** - Computer Show. Kern Co. Fairgrounds. MarketPro 415-456-6730

**CA - SAN FRANCISCO** - Computer Show. Cow Palace. Robert Austin 1-800-346-0100

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-In 619-561-0052

**CA - YUBA CITY** - Computer Show. Yuba-Sutter Fair. MarketPro 415-456-6730

**GA - WATKINSVILLE** - ARRL Hamfest. Athens Radio Club. David Alper 706-354-1952

**MD - WEST FRIENDSHIP** - Computer Show. Howard Co. Fgnds. MarketPro 301-984-0880 xt15

**MI - LIVONIA** - Super Computer Sales. Livonia Elks Hall. Computers & You 313-283-1754

**NY - BUFFALO** - Computer Show. Hamburg Fairground. MarketPro 201-825-2229

**NY - POUGHKEEPSIE** - Hamfest. Mt. Beacon ARC. Ken Akasofu 914-485-9617

**VA - ANNANDALE** - Computer Show. Northern VA Comm. College. MarketPro 301-984-0880 xt15

**VA - BRISTOL** - Computer Show. Viking Hall. MarketPro 301-984-0880 xt15

NOVEMBER 16-17

**CA - ONTARIO** - Computer Show. Holiday Inn. RCE 909-874-1722

**FL - WEST PALM BEACH** - Computer Show. South Florida Fairgrounds. MarketPro 301-984-0880 xt15

**GA - KENNESAW** - Computerfest. Georgia

Mountain Productions. 706-838-4827.

**IN - FORT WAYNE** - Hamfest. Allen Co. War Memorial Coliseum Expo Center. Don 219-484-1314

**MA - METHUEN** - Computer Show. Valley Expo Center. KGP Productions. 908-297-2526

**PA - MONROEVILLE** - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15

NOVEMBER 17

**CA - LANCASTER** - Computer Show. Antelope Valley Fairgrounds. MarketPro 415-456-6730

**CA - SANTA ROSA** - Computer Show. Sonoma Co. Fairgrounds. MarketPro 415-456-6730

**IL - ORLAND PARK** - Orland Park Computer Show. Civic Center. 24-Hour Hotline 708-974-3123

**KY - LOUISVILLE** - Computer Fair South. Executive West Hotel. MEKA Enterprises 812-333-9300

**MD - BALTIMORE** - Computer Show. BWI Airport Marriott. MarketPro 301-984-0880 xt15

**MI - DEARBORN** - Super Computer Sales. Civic Center. Computers & You 313-283-1754

**NC - BENSON** - JARSFest '96. American Legion Complex. 919-894-3352, 919-894-3100

**NY - POUGHKEEPSIE** - Hamfest. Mt. Beacon ARC. Ken Akasofu 914-485-9617

**NY - ROCHESTER** - Computer Show. The Dome Center. MarketPro 201-825-2229

**VA - NORFOLK** - Computer Show. Norfolk Scope. MarketPro 301-984-0880 xt15

NOVEMBER 20

**FL - ST. PETERSBURG** - ARRL Hamfest. Pelican Chapter #128 (QCWA). Don Bice 813-347-2702

NOVEMBER 22

**NJ - FAIR LAWN** - Hamfest. Fair Lawn ARC. Joe Sammartino 201-791-3841

NOVEMBER 22-23

**MS - OCEAN SPRINGS** - Hamfest/Swapfest. Latimer Comm. Center. C. F. Kimmerly 601-826-5811

NOVEMBER 23

**CA - OAKLAND** - Robert Austin Computer Show. Convention Center. 1-800-346-0100

**IL - BRADLEY** - Computer Show. The Ramada Inn. KRVCUG Gary 815-935-1605

**MD - BALTIMORE** - Computer Show. Martins Eastwind. MarketPro 301-984-0880 xt15

**MI - TAYLOR** - Super Computer Sales. Democratic Club Hall. Computers & You 313-283-1754

**NH - MANCHESTER** - Computer Show. Center of NH Complex. Northern Computer 508-744-8440

**NM - SOCORRO** - Hamfest. Socorro ARA. Howard Peavey 508-835-9653

**NY - WHITE PLAINS** - Computer Show. Westchester County Center. MarketPro 201-825-2229

**VA - ANNANDALE** - Computer Show. Northern VA Comm. College. MarketPro 301-984-0880 xt15

**VA - BRISTOL** - Computer Show. Viking Hall. MarketPro 301-984-0880 xt15

NOVEMBER 23-24

**FL - TAMPA** - Radio/Computer Conv. FL Expo Park, Expo Hall. Jean 813-525-5178

**KY - LEXINGTON** - Computer Show. Continental Inn. MarketPro 301-984-0880 xt15

**PA - ALLENTOWN** - Computer Show. Fairgrounds. MarketPro 301-984-0880 xt15

**PA - FT. WASHINGTON** - Ft. Washington Expo Center. KGP Productions 908-297-2526

NOVEMBER 24

**CA - SANTA ANA** - Swapmeet. ACP Parking Lot. Mary Russo 714-558-8813

**IL - GLEN ELLYN** - Computer Show & Sale. College of DuPage. Computer Central Shows 708-940-7547

**IL - WHEATON** - Radio Fest. DuPage County

NOVEMBER 24

**DECEMBER 1996**

DECEMBER 1

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857

**CO - DENVER** - Computer Show & Swap Meet. Jefferson

# Events CALENDAR

**MI - FLINT** - Computer Show. Holiday Inn, Gateway Centre. Five Star Productions. 810-230-0988

**MI - HAZEL PARK** - Hamfest. Hazel Park High School. HPARC Inc. Swap, POB 368, Hazel Park, MI 48030

**MI - LANSING** - Super Computer Sales. Holiday Inn S. Conv. Center. Computers & You 313-283-1754

**NJ - FAIRFIELD** - Computer Show. Fairfield Radisson. MarketPro 201-825-2229

**OH - DAYTON** - Computer Show. Montgomery Co. Fairgrounds. MarketPro 301-984-0880 xt15

**VA - CHANTILLY** - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15

## DECEMBER 6-7

**AR - HOT SPRINGS** - Arkansas DX Convention. Dave Jacques 501-760-1181

## DECEMBER 7

**AL - DOTHAN** - Hamfest. Wiregrass ARC. Joe Higginbotham 334-677-5439

**AZ - MESA** - Hamfest. Superstition ARC. Chuck Kruppenbacher 602-986-3060

**CA - SAN FRANCISCO** - Computer Show. Cow Palace. Robert Austin. 1-800-346-0100

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

**FL - OKEECHOBEE** - Hamfest. Okeechobee ARC. Al Berryman 941-467-0516

**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 317-299-8827

**IN - FT. WAYNE** - Computer Show. Allen County Fairgrounds. MarketPro 301-984-0880 xt15

**LA - MINDEN** - ARRL Hamfest. Minden ARA. Jimmy White 318-377-2501

**MA - WEST SPRINGFIELD** - Computer Show. Eastern States Expo. MarketPro 201-825-2229

**MI - SOUTHFIELD** - Super Computer Sales. Southfield Pavilion. Computers & You 313-283-1754

**MN - GOLDEN VALLEY** - Handi-Ham Winter Hamfest. Courage Center. Don Franz W0FIT 507-373-4745

**NC - GREENSBORO** - Hamfest & Computer Show. GGH 910-852-9244

**NH - SEABROOK** - Computer Show. Greyhound Park. Northern Computer 508-744-8440

## DECEMBER 7-8

**FL - TAMPA** - Computer Show. Florida State Fairgrounds. MarketPro 301-984-0880 xt15

**GA - ATLANTA** - Computer Show & Internet Seminars. N. Atlanta Trade Center 912-424-0808

**MD - NEW CARROLLTON** - Computer Show. Ramada Conf. & Exhibition Ctr 301-984-0880 xt15

## DECEMBER 8

**MA - HYANNIS** - Computer Show. Tara Cape Codder Hotel. Northern Computer 508-744-8440

**MI - GRAND RAPIDS** - Super Computer Sales. Crowne Plaza. Computers & You 313-283-1754

**OH - TOLEDO** - Computer Show. SeaGate Convention Centre. MarketPro 301-984-0880 xt15

**NY - POUGHKEEPSIE** - Computer Show. Mid-Hudson Civic Center. MarketPro 201-825-2229

**WI - GREEN BAY** - Swapfest. Ashwaubenon High School. Scott Cole 414-496-0989

## DECEMBER 8-9-10-11

**NV - LAS VEGAS** - Hamfest. Western USA & Mexico Chaverim Chapter. Irv Mirovich 818-986-9438

## DECEMBER 13-14-15

**MN - ST. CLOUD** - Computer Sale/Show. Civic Center. Blue Star Productions. 612-788-1901

## DECEMBER 14

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**FL - LAKE CITY** - Hamfest. Florida National Guard Armory. 904-755-7969

**IL - JACKSONVILLE** - Superfest. Jacksonville ARS c/o Kaye Green KB9HQ, 27 Ivy Wood Dr., Jacksonville, IL 62650

**NY - STONY BROOK** - Computer Show. SUNY Stony Brook. MarketPro 201-825-2229

**SC - COLUMBIA** - Hamfest. National Guard Armory. Roger W. Gregory 864-427-1462

**VA - HAMPTON** - Computer Show. Hampton Coliseum. MarketPro 301-984-0880 xt15

## DECEMBER 14-15

**FL - FT. LAUDERDALE** - Computer Show. War Memorial Auditorium. MarketPro 301-984-0880 xt15

**GA - PERRY** - Computer Show. Georgia National Fairgrounds & Agricenter. 770-907-6225

**IL - CHICAGO** - Computer Show. Higgins Archer Show Promotions 1-800-672-3472

**IL - ORLAND PARK** - Orland Park Computer Show. Civic Center. 24-Hour Hotline 708-974-3123

**KY - LOUISVILLE** - Computer Show. Commonwealth Conv. Center. MarketPro 301-984-0880 xt15

**PA - HARRISBURG** - Computer Show. Harrisburg Farm Show Complex. MarketPro 301-984-0880 xt15

**VA - CHANTILLY** - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15

## DECEMBER 15

**NH - SALEM** - Computer Show. Rockingham Park Race Track. Northern Computer 508-744-8440

**NJ - SECAUCUS** - Computer Show. Meadowlands Expo. Center. MarketPro 201-825-2229

**VA - RICHMOND** - Computer Show. The Showplace. MarketPro 301-984-0880 xt15

## DECEMBER 21

**CA - OAKLAND** - Computer Show. Convention Center. Robert Austin 1-800-346-0100

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

**MA - ROCKLAND** - Computer Show. Sons of Italy Hall. Northern Computer 508-744-8440

**NH - NASHUA** - Computer Show. Rivier College. MarketPro 201-825-2229

**VA - ANNANDALE** - Computer Show. Northern VA Comm. College. MarketPro 301-984-0880 xt15

**VA - BRISTOL** - Computer Show. Viking Hall. MarketPro 301-984-0880 xt15

## DECEMBER 21-22

**FL - ORLANDO** - Computer Show. Central Florida Fairgrounds. MarketPro 301-984-0880 xt15

**GA - ATLANTA** - Computer Show. Farmers Market. Alan Westberry 770-297-9256

**PA - ALLEGTON** - Computer Show. Allentown Fairgrounds. MarketPro 301-984-0880 xt15

**PA - PITTSBURGH** - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15

## DECEMBER 22

**CT - FARMINGTON** - Computer Show. Farmington Marriott. MarketPro 201-825-2229

**MA - TAUNTON** - Computer Show. Holiday Inn. Northern Computer 508-744-8440

**MD - UPPER MARLBORO** - Computer Show. The Show Place Arena. MarketPro 301-984-0880 xt15

**MI - FLINT** - Computer Show. Holiday Inn, Gateway Centre. Five Star Productions. 810-230-0988

**VA - ROANOKE** - Computer Show. Roanoke Civic Center. MarketPro 301-984-0880 xt15

## DECEMBER 23

**NH - MANCHESTER** - Computer Show. Center of NH Complex. Northern Computer 508-744-8440

## DECEMBER 28

**CA - SAN FRANCISCO** - Robert Austin Computer Show. Cow Palace. 1-800-346-0100

**MD - BALTIMORE** - Computer Show. Martin's Eastwind. MarketPro 301-984-0880 xt15

**OH - DAYTON** - Computer Show. Montgomery County Fairgrounds. MarketPro 301-984-0880 xt15

## DECEMBER 28-29

**FL - MELBOURNE** - Computer Show. Melbourne Civic Auditorium. MarketPro 301-984-0880 xt15

**MD - GAITHERSBURG** - Computer Show. Montgomery Co. Fgnds. MarketPro 301-984-0880 xt15

**PA - KING OF PRUSSIA** - Computer Show. Valley Forge Conv. Center. MarketPro 301-984-0880 xt15

## DECEMBER 29

**MD - TIMONIUM** - Computer Show. Maryland State Fairgrounds. MarketPro 301-984-0880 xt15

**OH - COLUMBUS** - Computer Show. Ohio Expositions Center. MarketPro 301-984-0880 xt15

## JANUARY 1997

### JANUARY 4

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in 619-561-0052

**NH - PORTSMOUTH** - Computer Show. Frank Jones Center. Northern Computer 508-744-8440

### JANUARY 4-5

**FL - CAPE CORAL** - Hamfest. Ft. Myers ARC. Jackie Kampfert 941-542-6675

**KY - LEXINGTON** - Computer Show. Continental Inn. MarketPro 301-984-0880 xt15

**PA - MONROEVILLE** - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15

**VA - CHANTILLY** - Computer Show. Capital Expo Center. MarketPro 301-984-0880 xt15

### JANUARY 5

**CA - LIVERMORE** - Swapmeet. Las Positas College. Noel Anklam 510-447-3857

**IN - SOUTH BEND** - Hamfest. Michiana Valley Hamfest Assn. Bob Denniston 219-291-0252

**PA - DICKSON CITY** - Computer Show. Genetti Manor. MarketPro 301-984-0880 xt15

**PA - MONROEVILLE** - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15

### JANUARY 11

**AZ - GLENDALE** - Hamfest. Glendale Community College N. Lot. Mark KC7BXS 602-931-1204

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**NY - MARATHON** - Computer Show. Skyline ARC. 607-849-6751

Continued on page 104

# ELECTRONIC TEST EQUIPMENT BOUGHT & SOLD

Alitech 360D11, Frequency Syn...01-2GHz	\$1,000	HP 8620C, Sweeper Mainframe	\$400
Anritsu ME645A, Microwave Radio Test Set	\$1,000	HP 8621B, RF Draw, with 86350A, 8-12.4GHz, 8620C	\$400
Arbitr 1040A, Meter Calibrator, AC/DC/Voltage/Current	\$1,200	HP 86220A, RF Plug-in, 10-130MHz	\$600
Argosystems AS210, Frequency Calibration System	\$3,500	HP 86222B, RF Plug-in, .01-2.4GHz, Opt. 02, 04	\$1,200
Balco 911A, Frequency Response Analyzer (unused)	\$400	HP 86241A, RF Plug-in, 3.2-6.5GHz	\$400
Ballantine 1627A, Scope Calib., with acc. heads	\$1,000	HP 86250C, RF Plug-in, 8-12.4GHz	\$400
Boonton 4200, Power Meter, w/Detector, 100KHz-18GHz	\$800	HP 86290B, Signal Gen., 5-1024MHz Opt. 1, 2, 3	\$2,000
Boonton 42BD, Microwattmeter, 2MHz-7GHz	\$300	HP 8640B, Signal Gen., 5-12MHz, Opt. 3	\$1,000
Boonton 82AD, Modulation Meter, 1.2GHz, HPIB	\$650	HP 8640B, Signal Gen., 5-12MHz, Opt. 3	\$1,000
Boonton 92A, RF Millivoltmeter w/Probe	\$300	HP 8654A, Signal Gen. 10-520MHz AM/FM	\$500
Bruel & Kjaer 1612, Bandpass Filter	\$250	HP 8660A/100, Synth. Freq. Gen. Mainframe	\$650
Bruel & Kjaer 2107, Frequency Analyzer	\$200	HP 8660C/100, Synth. Freq. Gen. Mainframe	\$1,200
Bruel & Kjaer 2305, Level Recorder	\$250	HP 8660B/100, Synth. Freq. Gen. Mainframe	\$800
Cushman CE24B, Frequency Selective Voltmeter	\$800	HP 86601A, RF Plug-in, 110MHz	\$250
Cushman CE6-6030, Com. Monitor, with Opt. 05, HPIB	\$5,000	HP 86602B, RF Plug-in, 1300MHz	\$600
DDC SR-400, Syncro Resolver Simulator	\$400	HP 86603A, RF Plug-in, 1-2600MHz, Opt. 02	\$1,500
DR Thiedig MILLI-T02, Ohmmeter, 1 Million-2 Terraohms	\$400	HP 86632B, Modulation Plug-in	\$400
Eaton 380K11, Synthesizer, 1-2000MHz	\$2,500	HP 86750A, Storage Normalizer	\$250
Opt. 01, 03, 183		HP 8821A, Medium Gain Bank Amp	\$150
EIP 371, Source Locking Microwave Counter, 18GHz	\$1,500	Ihaco 393, Lock-in Amplifier	\$300
EIP 451/P1/P2/P3, Microwave Pulse Counter, 18GHz	\$700	Keithley 261, Pilo Amp. Source (unused)	\$300
ESI 296, Auto LCR Meter	\$550	Keithley 614, Electrometer	\$700
Fluke 3330B, DC Voltage, Current Calibrator	\$400	Kepco ATE-100-1M, Power Supply, 0-100V, 0-1 amp (new)	\$200
Fluke 335A, DC Voltage Standard, 0-1100VDC	\$600	Leeds & North 1091, Capacitor Decade, .001uF-1uF	\$150
Fluke 5200A, Programmable AC Voltage Standard HPIB	\$1,600	Marconi 2955, Radio Comm. Test Set, OCXO	\$5000
Fluke 540B, Thermal Transfer Standard	\$900	Micro-Tel SG800, Sweep Signal Generator, 1-18GHz	\$2,000
Fluke 750A, Reference Divider	\$600	Narda 7000A/7202/7206, Microwave Multimeter,	
Fluke 8500A, Digital Multimeter, 6.5 Digits, DC Only	\$250	Narda 792F, Attenuator, 2-12.4GHz 0-20dB	\$100
Fluke 8505A, Digital Multimeter, AC, DC, Ohms	\$400	North All 540/10, Resistor Synchro Bridge	\$600
Fluke 8821A, Digital Multimeter, AC, DC, Ohms	\$400	Phillips 3211, Scope, 15MHz 2Ch.	\$200
Fluke 8921A/03, True RMS Voltmeter	\$600	Phillips PM3267, Scope, 100MHz Dual Trace	\$400
Fluke 9010A, Micro-System Troubleshooter Opt. 001	\$450	Polarad 1100, ESR, Sig. Gen. 10-520MHz	\$1,000
Fluke A55, Thermal Converter Set, 7 Pieces, Cables	\$1,800	Polarad 1105 E-L, Sig. Gen., 102	

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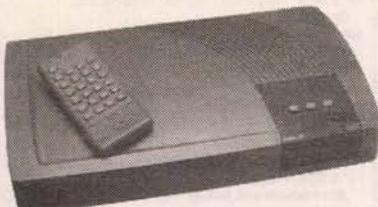
Write In 112 on Reader Service Card.

# SIGMA

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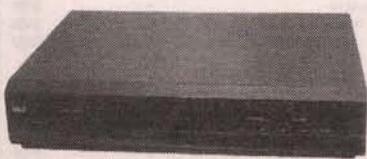
OAK Sigma 3D (3 button and full keypad)  
OAK Sigma 2000  
TV/COM Sigma One (3 button)  
TV/COM Cable Cinema 2001



- All areas
- All channels
- All functions (Parental Lock, etc.)
- Easy installation/removal \*
- Self contained / Non destructive
- Does not 'time-out'
- Operates in 'dead' units

\* Requires a one time desoldering of a 40 pin DIP chip, and soldering of a 40 pin DIP socket per converter.

Converter can be returned to normal operation in a few seconds!



Use the one that **WORKS !!**  
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1 \$225  
2 - 4 \$200  
5 - 9 \$175  
10 - 19 \$150  
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### Telephone Call Restrictor

Connects to telephone wall jack. Disables all phones on the line if attempting to either: dial a number that has been stored in memory "Block Group" mode or, dial a number that has not been stored in memory "Allow Group" mode. Use touch-tone phone to enter telephone numbers (or prefix) into non-volatile memory, and choose mode. Program or disable from any phone on the line using your private 4-digit password. \$35.00

### Caller ID / Computer Interface

Connects between a telephone wall jack and an RS-232 serial port. Decodes the caller ID data sent over the phone line and sends it to your PC/Mac in a pre-formatted ASCII character string. Create your own program to log the name, number, date, and time of all incoming calls. Block out unwanted callers to your BBS/modem. \$34.50

### 50 MHz Frequency Counter

Reads frequency from 1Hz to 50MHz and displays up to 7 digits on a 16x1 character LCD display. Auto-range feature provides floating decimal point and automatic placement of suffix (Hz, kHz, or MHz). Microcontroller based; allows for highly stable readout and very small parts count, board only 2" x 3" big. \$46.50

### RS-232 Digital Input/Output

Give your home-brewed PC/Mac programs a link to the outside world! 12 I/O pins can be configured individually for input or output. Turn on/off relays, triacs, etc. Response to button presses, switch changes, 4x4 matrix decoding with auto-debounce. Stack up to 16 units on the same serial port for a total of 192 I/O points. \$32.00

### IR Remote Control Receiver

Learn and records the data patterns emitted by standard infrared remote controls used by TVs, VCRs, Stereos, etc. Lets you control all your electronic projects with your TV remote. Seven individual I/O pins can be assigned to any button on your remote, and can be configured for either "toggle" or "momentary" action. Re-program over and over for use with different remote transmitters or configurations. \$32.00

### DTMF Decoder/Logger

Keep track of all numbers dialed or entered from any phone on your line. Connects to your telephone wall jack. Decodes all 18 touch-tones and displays them on a 16-character LCD display. Holds the last 240 digits in a non-volatile memory. Scroll through and view all telephone numbers dialed, credit card numbers entered, etc. Can also be connected directly to radio receiver's speaker jack. \$54.50

### TEST EQUIPMENT cont.

**POWER SUPPLIES:** SORENSEN, LAMDA, HP, etc. \$ CALL. BIDDLE 222060 DIELECTRIC TESTER (60KV) \$ CALL. ESTERLINE ANGUS MINISERVO III POWER SURVEY ANALYZER \$ CALL. FLUKE 335D, DC VOLTAGE STANDARD \$750. FLUKE 4265A PROGRAMMABLE POWER SUPPLY \$150. FLUKE 5200A AC VOLTAGE STANDARD \$1,500. FLUKE 5205A AC VOLTAGE STANDARD \$1,500. HIPOTRONICS 820-50 HV P/S (20KV, 50mA) \$ CALL. HP 54200D DIGITIZING SCOPE \$1,000. HP 8620C SWEEPER MAINFRAME (W/DIALS) \$300. HP 86222A RF PLUG-IN .01-2.4 GHz \$400. HP 86230A RF PLUG-IN 1.8-4.2 GHz \$400. HP 86241A RF PLUG-IN 3.2-6.8 GHz \$400. HP 86260A RF PLUG-IN 12.4-18 GHz \$450. HP 3490A DMM \$100. HP 3495A SCANNER \$100. TEK 465 SCOPE (100MHz) \$400. TEK 7A13 VERTICAL PLUG-IN \$150. TEK 7A26 VERTICAL PLUG-IN \$100. TEK 7B80 TIME BASE (400MHz) \$100. TEK 7B85 TIME BASE (400MHz) \$100. TEK PS503A DUAL TRACKING POWER SUPPLY \$125. FLUKE 5450A PROGRAMMABLE RESISTANCE STANDARD \$1,500. Instrument Service Laboratories, 680 Haines Avenue NW, Albuquerque, NM 87102. 505-842-1107.

**ELECTROMAGNETIC DETECTORS**, including Trifield® broadband meter (analog) reads field strength of 10-1000 V/M at 100KHz 2.5GHz, also independently reads magnetic (3-axis) and electric fields, below 100KHz. 0.2-100 milliGauss, and .5-100 KV/M, at 60 Hz. Ideal general detection tool for both AC power and RF work \$170 postpaid. **Atmospheric Ion counter** (digital) reads both polarities 10-2,000,000 ions/cc. (Atmosphere is typically 300-5000 positive and 200-3000 negative. Depends on weather, etc.) For the first time, under \$4,000 for a true ion counter! \$480 postpaid. **DC Gaussmeter** (digital) includes compact Hall probe (.01-20,000 Gauss) and differential coil probe (.01 milliGauss - 20 Gauss). Complete \$265 postpaid. All above have 1 year warranty and include 9-volt batteries. Made in USA by Alphalab Inc., 1280 South 300 West, Salt Lake City, UT 84101. Tel. 1-800-769-3754 or 801-487-9492. Free catalog.

**HP 141T**, 8555A, 8552B, \$2,000; **HP 141T**, 8554B, 8552B, \$1,800; **HP 8553B**, \$500; **HP 8660A**, \$250; **HP 86290A**, 2-18 GHz, sweep plug-in, \$1,800; **HP P532A**, wavemeter, \$150; **Scientific Atlanta** programmable microwave receiver, with digital phase gain meters, phase meters, \$2,500; **Fluke 332B** voltage calibrator, \$600; **HP 3320B**, \$400; **HP 3330B**, \$500; **Rockland 5100 synthesizer**, \$400; **HP 334A**, distortion ana., \$450; **HP 332A**, \$300; **HP 331**, \$250; Send for test equipment sales list. A-Comm Electronics, 7198 S. Quince Street, Englewood, CO 80112. 303-290-8012.

### FREQUENCY COUNTER: HP 5383A, \$225.

HP 5326A, \$425. HP 5328A/096, \$525. HP 5328A/098, \$575. HP 5340A, \$1,200.

### METERS: HP 3400A, \$200. HP 3490A, \$195. Boonton 93A, \$195. HP 334A, \$395.

Boonton 42CD/41-E, \$795. HP 3406A, \$395. HP 8405A, \$600. Fluke 8375A, \$250.

Dana 5100, \$295. Ballantine 3015, \$150.

### OSCILLOSCOPES: Tek 453, \$295. Tek 455, \$350. Tek 465M, \$450. Tek 475, \$625. HP 1725A, \$550. HP 1741A, \$550. Tek 1106, \$150.

**GENERATORS:** HP 204C, \$125. HP 652A, \$195. HP 8005B, \$395. Wavetek 148A, \$695. URM25J, \$175. Logimetrics 925/S125, \$595. HP 8660A mainframe, unused, \$495. Wavetek 3000-200, \$750.

### MISCELLANEOUS: Systron/Donner spectrum analyzer, .01 to 12.4GHz (712-2A display + 809-2A tuning unit) \$1,400. Fluke 407DR, \$295. Tektronix Y-T chart recorder, \$195. Technical Services & Materiel, Gary N6ZD, 408-385-0301, FAX 408-385-0261, GaryN6ZD@aol.com VISA & MASTERCARD cards accepted.

### TEKTRONIX EQUIPMENT: 184 time mark generator, \$150; 109 pulse generator, \$100;

106 squarewave generator, \$200; 130 LC meter, \$200; 475A, 250MHz scope, \$800;

620 XY display, \$250; dual 620 side by side

rack mount, \$500; 634 video display, \$250;

7603 3 slot frame, \$250; 7904 500MHz 4 slot

frame, \$500; 7834 400MHz storage frame, \$500; TM506, \$200, TM504, \$150; TM503, \$130; 7623, 7A26, 7A26, 7B53A, \$650;

7A11, \$300; 7A26, \$200, 7A19, \$150; 7B80,

\$200, 7B92A, \$250; C51 camera and back

for 7000 series scopes, \$150; DM501A 4.5

dig DVM, \$200, FG503, \$300; R468 100MHz

dual channel 10MHz dig storage, \$600;

PG501, 50MHz pulse gen., \$200; PS501-2,

\$150; PS503A, \$200, T922, 15MHz dual

channel scope, \$200; TM515 5 slot frame, \$250; SG502, \$300. A-Comm Electronics

303-290-8012.

### TEST EQUIPMENT SALE: The following equipment is offered at \$250 each PPD CONUS.

All items include manual, accessories and have been lab tested. DATA Precision 3500 5-1/2 digit DVM, GR 1236 IF Amplifier, GR 1531AB Strobotac, ENI 300L Amplifier, FLUKE 1953A Frequency Counter,

HP 432A Power Meter plus cable, HP 435A Power Meter plus cable, HP 428B Milliammeter w/probe, HP 400F AC Voltmeter,

HP 400FL AC Voltmeter, HP 182C Oscilloscope Mainframe, HP 652A Test Oscillator, HP 608E signal Generator, HP

606A Signal Generator, HUNTRON TRACKER 1005B-S1, KROHN-HITE 4100 Pushbutton Oscillator, TEKTRONIX 7603 Mainframe, TEKTRONIX 575 Curve Tracer,

WAVETEK 154 Function Generator. Call/Fax/

E-Mail Brian at Kentronix 908-681-3229, 908-681-3312 Fax, brian@kentronix.com E-Mail,

Po Box 2444, Farmingdale, NJ 07727.



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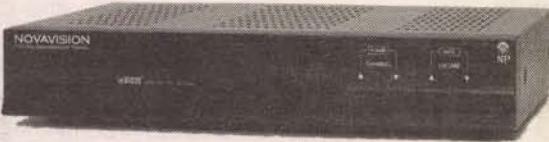
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# BEAMING IN WINTER WEATHER MAPS AND SATELLITE IMAGERY ON YOUR PC

You can watch the winter weather storms direct from the airwaves without having to spend a penny on land-line Internet access. The weather facsimile signals come right off of the radiowaves, and reception is free. (You already paid for it with your taxes!)

"Radio facsimile" is the descriptive term for sending pictures and weather maps over radio frequencies. You have your choice of which radio bands you are going to tune in for weather facsimile imagery. See Table 1.

To get started with any of these three weather satellite reception capabilities, here are the easily met requirements for your monochrome or color computer:

IBM PC or truly compatible MS-DOS Version 3.3 or higher 640K RAM, hard disk drive Serial port, parallel printer (optional) Video display: Hercules, CGA, EGA, VGA, or SVGA

If your present computer runs rings around what we have just listed, all the better and all the faster. But what we just listed could very well be found in that old computer sitting in the corner gathering dust. And, by the way, that older monochrome lap-top should work just fine, too.

When it comes to the radio receiver that's going to pull these weather images out of the airwaves, your choice will either be a simple shortwave receiver with capabilities for upper sideband, or the other method of pulling the signals direct from orbiting or geosynchronous satellites may require nothing more than a simple modified scanner, or a scanner combined with a downconverter.

So where do we go from these analog signals over to digital that your computer will accept? A little A/D converter sits inside the serial port connector, and all of the number crunching is accomplished with a software disk. We are not talking about thousands of dollars for receiving weather facsimile, but rather only a couple hundred dollars that could get your computer on the air with a simple portable Radio Shack shortwave receiver and the weather facsimile

software stuff which also comes with the A/D serial port plug.

## HIGH FREQUENCY 3 MHz-30 MHz

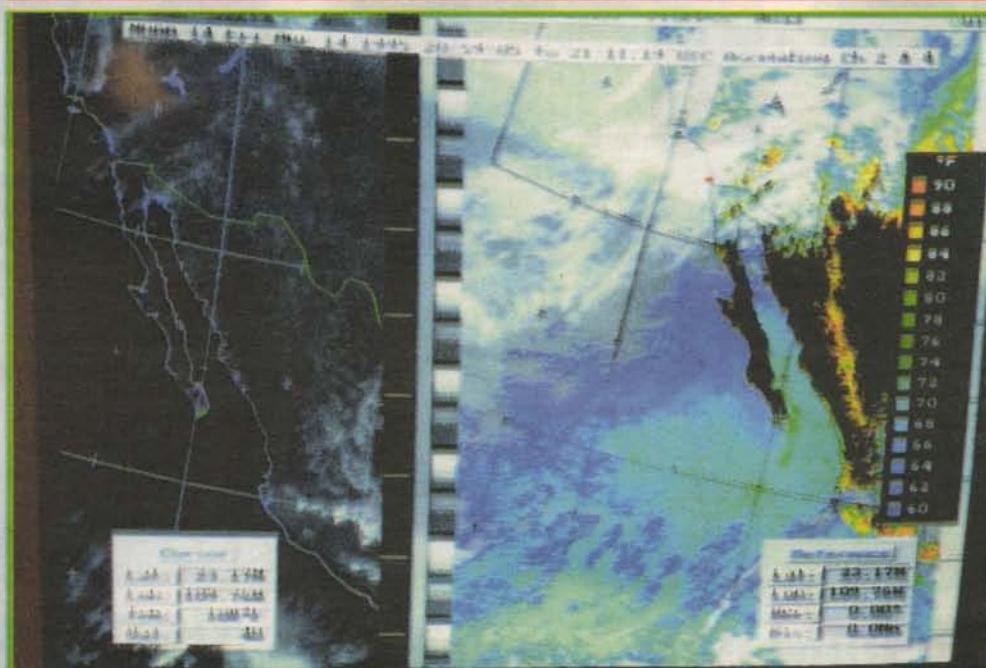
Powerful weather facsimile signals are beamed out by more than 40 worldwide transmitting stations. Serving the United States are these powerful military and government transmitter sites (see Table 2 for coast frequencies):

**Kodiak, AK**  
**Esquimalt, B.C., Canada**  
**San Francisco, CA**  
**Honolulu, HI (Navy)**  
**Honolulu, HI (Government)**  
**Guam**  
**Frobisher, Canada**  
**Boston, MA**  
**Norfolk, VA**  
**New Orleans, LA**

This is just for the United States. There are

TABLE 1: RADIO BANDS

EASY!	GOT A SCANNER?	EXPENSIVE
High Frequency Upper Sideband 3 MHz-30 MHz	VHF Medium Bandwidth FM 137.5 MHz Range	Ultra High Frequency Narrow Band FM/AM 1691 MHz
Signals from earth transmitters	Direct from low earth orbit satellites	Direct from geostationary satellites



This is the imagery you can pick up at 137.5 MHz from low earth orbit satellites.

hundreds of additional frequencies throughout the world for their own regional broadcasts.

These powerful transmissions are so strong that you can pick them up with a portable shortwave receiver in the upper sideband mode.

Unfortunately, this rules out that little portable shortwave set someone gave you last year that picks up Voice of America and WWV. If it doesn't have a beat frequency oscillator, or provisions for single sideband, it won't decode the weather facsimile signals. Portable sets with a beat frequency oscillator for single sideband reception include the Radio Shack DX-392, DX-390, DX-394, and the Grundig "Yacht Boy." You could also score almost any kind of older plug-in shortwave set that has a BFO to tune in worldwide weather facsimile signals. Older sets don't feature digital tuning, so stability and precise frequency spotting may be a challenge. Newer ham sets with a general coverage receiver all pull in weather facsimile signals on the worldwide bands, loud and clear.

Try tuning in any one of those frequencies I gave you for the East Coast, Gulf, or West Coast. For those of you inland, all three should come in loud and clear sometime during the day or night. These stations are not necessarily transmitting 24 hours a day, but rather for a couple of hours straight with two or three hours of dead air or CW in between.

What you will hear is a twice-a-second sweeping sound with audio tones between 1400 Hz and 2200 Hz; 1400 Hz will make your computer read black, and 2200 Hz makes it read white. Everything in between is shades of gray.

The undisputed weather facsimile software guru is John Hoot of Software Systems Consulting, San Clemente, CA; 714-498-5784. It's a family-run business, and John and his wife, Lala, live and breathe weather facsimile and digital communication modes. Their PC HF facsimile 7.0 plus sells for \$129.00, and gives you everything you need to pull in weather charts, satellite images, wire service photographs, decode Morse Code, radioteletype, NAVTEX, and ham and marine telex over radio modes. The product includes a frequency shift key demodulator, 9 dB-25 dB adaptor, computer software, instruction manual, worldwide broadcast schedule including frequency and times(!), and even a tutorial audio cassette where Big John will sooth you through the hook-up and ultimate reception.

Just keep your portable receiver or antenna away from the computer — if you get them too close together, the noise out of the computer can wreck high-frequency reception. Try the radio outside first, or with the computer off, tune into the weather facsimile signals, and then stand by.

- Satellite imagery
- Surface weather analysis and pressure systems

- Surface weather prognosis for 24 and 36 hours
- Extended surface prognosis for up to five days
- Ocean wave analysis, including height and direction
- Iceberg analysis, or water temperature zones
- Low and high pressure systems, 500 millibar readout
- Hurricane tracking

It takes about 10 minutes for a complete picture to form up on your screen. But when it does, you will be impressed. The imagery and weather charts are seldom more than a couple of hours old.

### REAL-TIME LOW-EARTH ORBIT SATELLITE IMAGERY

Low-earth orbit (LEO) satellites circle the earth from north to south, passing over the poles at altitudes between 300 and 500 miles up. This orbital pattern allows the earth to turn under the satellites as they sweep around the earth. The pattern allows the satellite to map a strip of the earth a bit further west on each pass. Each satellite images the entire planet twice a day. LEO images are transmitted to earth on or around VHF/FM frequency 137.5 MHz. A relatively simple omnidirectional antenna and a scanner radio could allow you to decode this imagery as the satellite passes overhead twice a day.

The satellite image you receive on your computer is both infrared and visible light. The images are high resolution, and a typical pass will offer an image covering 2500 x 1500 miles. Stand outside and wave — you could just about see yourself.

Presently, there are four NOAA satellites transmitting from low-earth orbit, and one Russian satellite transmitting with two standby units. The Chinese have previously had two such satellites, and expect to launch another shortly. This gives approximately 10 or more passes that you can receive EVERY DAY!

If you have a scanner, tune into 137.5 MHz, and see what you hear. You will get a morning pass, and an afternoon pass that will last about 10 minutes. You will hear a rapidly fast sweeping sound, and this is a combination of wide-band FM at around 35 KHz-42 KHz, with audio frequency shift keying to develop the satellite imagery on your computer screen. A 3 KHz Doppler shift will occur as the satellite is approaching you, and then turn into zero KHz at overhead, and a -3 KHz Doppler shift occurs as the satellite travels away and over the horizon. This is why wider bandwidths within your scanner IF are required to capture this relatively wide signal. Removing one of the filters in the scanner section is a good way to open up the IF section. John and Lala Hoot can give you details if you are getting one of their 137.5 LEO systems. The polar-orbiting software and demodulator is a little bit more expensive than the high-frequency set-up, but you

**TABLE 2: COAST FREQUENCIES**

East Coast Weather FAX Frequencies (USB)	Gulf Coast	West Coast Weather FAX Frequencies (USB)
10,863.2 KHz	8502 KHz	4344.1 KHz
12,748.1 KHz	12,787 KHz	8680.1 KHz
8078.1 KHz	17,146.4 KHz	12,728.1 KHz
15,957.1 KHz		11,088.1 KHz
11,120 KHz		16,133.1 KHz
12,743.6 KHz		9980.6 KHz
6338.6 KHz		
9108.1 KHz		



Add-on digital signal processors will help clear up weather fax imagery in noisy conditions.

can talk with John and work up a package that will fit what you already have in your lap-top or fixed computer.

You will also need a ground plane antenna with an additional ground reflector one-quarter wavelength below the feedpoint. This creates an overhead reception pattern, and increases the capabilities to hear the satellite when it comes up

over the horizon, goes overhead, or to either side of you — and then disappears over the other horizon. There is also a 137 MHz quadrifilar antenna that's available for around \$150.00, and this really does the job nicely. It looks like an egg-beater on your roof. But what the heck, your neighbors have probably already given up on your radio hobby. If you need a wideband scanner receiver, that too can cost up to \$150.00. A turn-key system would be \$500.00 where all you need is your computer and some sort of alibi as to what in the world that is on your roof.

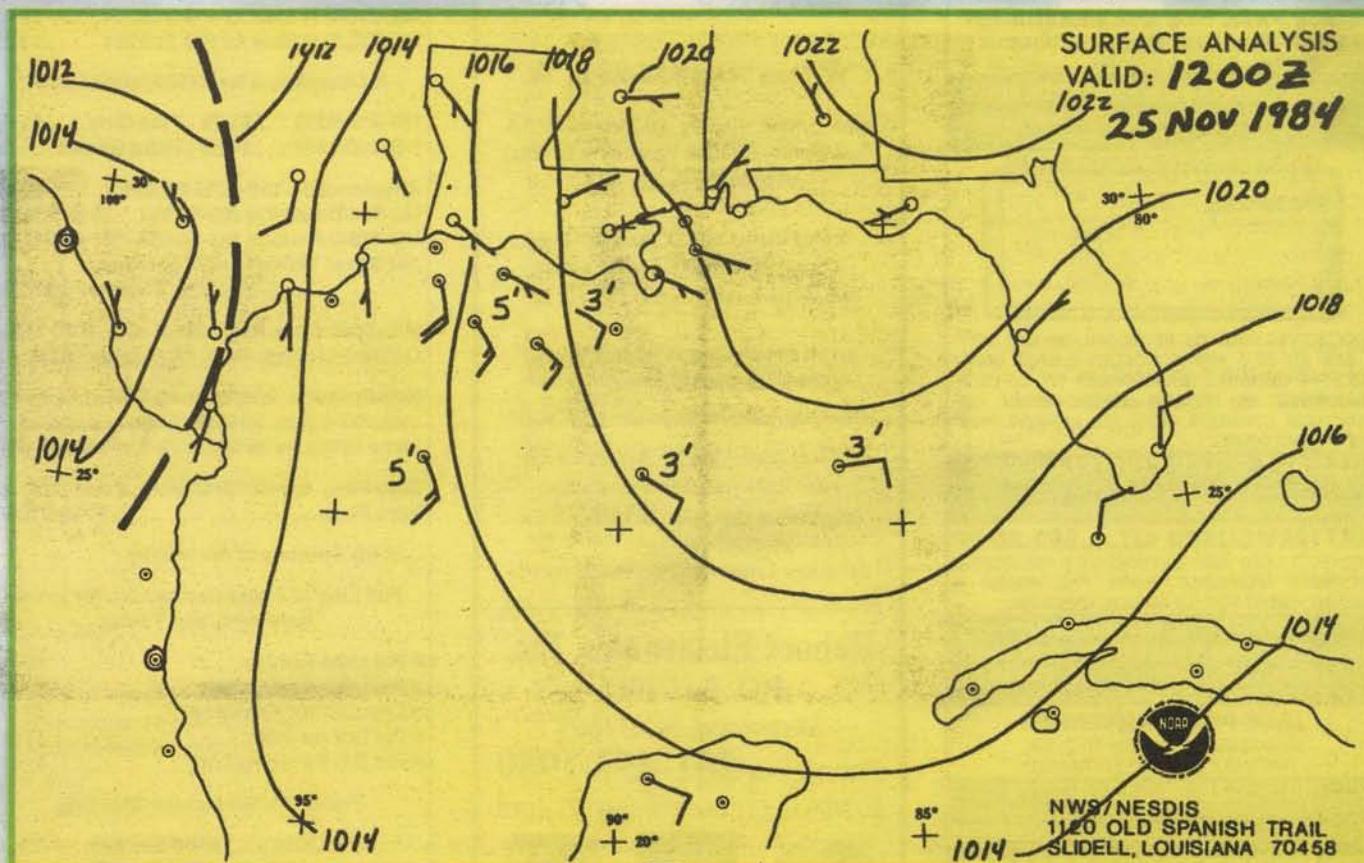
The polar-orbiting satellites won't give you Weather Bureau charts. What you are receiving is real-time directly from the satellite. You won't even receive satellite state lines, because the last time I looked from space, state lines weren't visible. However, your computer with the John Hoot program can calculate the satellite orbit, calculate time and your place, and re-insert the lines of every state in the union.

Polar-orbiting satellite imagery is so detailed and so good that a color computer can even show

areas of cold and warm, dry and wet, and rain and snow. For boaters, it will also show water temperature colors, too.

### 1691 MHz

Here is where your local television weather forecaster tunes in to display weather maps on the



High Frequency reception of a gulf coast weather fax chart.

evening news. Geostationary satellites are parked along the Equator, and they relay earth imagery from the National Weather Service. These satellites transmit in the S-band microwave region at 1691 MHz, and send a complete image every five minutes.

The National Weather Service gives us an exciting one hour of programming, five minutes a picture, with 12 views of the entire globe every hour. In one five-minute slot, you are looking down at the United States. Next shot, you're looking down at the Red Sea. Next shot, you are over Africa, and next shot, you are down at South America. If you're interested in viewing worldwide weather from space, this is the place to be.

You get about three shots an hour of the United States. This satellite imagery is only a few minutes old, and you can capture hourly shots and create your own nighttime news weather report in live-action, freeze-frame progression.

The images also include state borders, latitude and longitude lines, and country borders. You have up to three GOES (geostationary satellites) to capture with your loop Yagi antenna system. I like GOES 8 at 75 degrees west because it gives me terrific shots of all of the United States. GOES 9 at 135 west is a little too far off the coastline to let me see what's happening on the East Coast, but try it and see if you like it.

You will need a loop Yagi to tune in the 1691 MHz satellites. You don't need a dish. But if you have one, try it. The loop Yagi gives you a couple degrees "fudge factor" so you don't have to be right-on. But you need a clear shot at the sky without trees, buildings, or your neighbor's house in the way. But these are up relatively high, similar to your direct satellite television dish orientation, so you

### Weather Satellites

Frequency	Satellite	Country
137.300	Meteor	Russian
137.400	Meteor	Russian
137.500	NOAA 10/12	American
137.620	NOAA 9/11	American
137.795	FENGYUN	China
137.850	Meteor	Russian

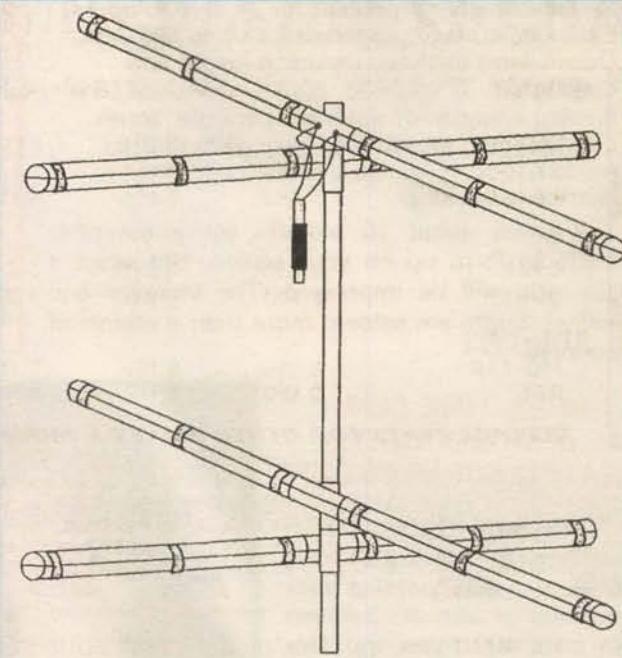
shouldn't have a problem. Your loop Yagi doesn't need to be real high on the roof — I keep mine down low so the neighbors won't see it.

The expensive part of GOES reception is the downconverter that takes 1691 MHz and downconverts it to 137.5 MHz to use with the same scanner you are tuning in the polar-orbiting satellites. The loop Yagi antenna is around \$135.00, and offers 20 dB gain on a boom length of 110 inches. It doesn't quite compete with the slightly more expensive dish antenna, but 20 dB gain gives you plenty of signal to work with.

Now make sure you are sitting down. The 1691 MHz downconverter costs a lot. \$575.00. But you can't do without it unless you have one of those Kenwood or ICOM several-thousand-dollar receivers that make it all the way up to 2000 MHz. The downconverter mounts out of the way, close to the loop Yagi, and squirts out signal at 137.5 MHz for easy geostationary satellite reception.

### GET STARTED NOW

I suggest starting with high-frequency reception. If nothing else, put down *Nuts & Volts*



137.5 MHz low earth orbit satellite antenna.

and listen to the rhythmical sweeping sounds on HF, and imagine everything that you could see on your computer. Then start out tuning in HF weather imagery from powerful shortwave stations. Then graduate up to polar-orbiting satellites for a close look at exactly WHERE you are. And then if you really get into this, go for geostationary satellite reception, but don't throw out the HF Receiving HF weather facsimile really gives you the best of all worlds centered on East Coast, Gulf Coast, or the West Coast of the United States. NV

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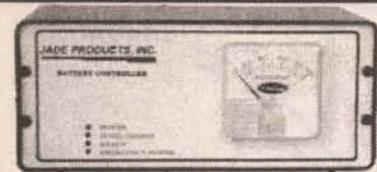


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by  
**Harry Helms**

**W**

alk into the computer books section of any bookstore today and there will be dozens of titles on Java, the hot new language for developing applications software distributed over the World Wide Web. Java was created by Sun

# Software wizardry

Microsystems, and is touted as the language that will break Microsoft's stranglehold on the software industry by making operating systems irrelevant and allowing people to "rent" software (or "applets" as they're called in Java-speak) over the Web instead of buying it. Learning Java is the cool thing to do if you're a software developer, and a lot of industry savants predict that a knowledge of Java is soon going to be essential for any software developer. And a lot of venture capital is flowing into new companies developing software applications and tools based on Java.

Unfortunately, all the excitement about Java is largely hype, bunkum, and hooey. Java is a long way from being a "must know" language like C, and the vision of a glorious, Microsoft-free world of Web-based computing might turn out to be as accurate a picture of the future as the old "The Jetsons" television series. For a lot of reasons — detailed in the sidebar accompanying this column — all that effort people are spending learning Java in order to do Web-based programs might turn out to be largely wasted.

However, Java has a little brother, known as JavaScript, that shows promise of being far more useful than Java itself. Microsoft also thinks JavaScript is a good idea, since it is rushing out a similar product of its own called VBScript. If you think there's a future in making applications software available over the Web, forget about learning Java. JavaScript and possibly VBScript are really the ways to go.

## Making HTML Less Dumb

The standard "language" for creating Web pages is hypertext markup language (HTML). I put the word "language" in quotes for a reason: HTML really isn't a programming language; it is more like the codes used for years with typesetting machines. HTML is brain-dead compared to a minimalist programming language like BASIC. HTML describes how a document will look on a PC monitor — type fonts, type sizes, colors, where images will be displayed — but that's about it. About all the interactivity you can find in an HTML document are hotlinks to other pages or Web sites.

If you're going to make a Web page do much more than sit and stare at users, you need something more than HTML.

Is Java the answer? While I feel Java has been oversold, it is also

a serious programming language suitable for a wide range of development tasks.

You can include links to a Java program in a HTML document, and that Java program can be just as powerful and complex as anything developed using a language like C++. But that points out Java's main weakness: Java is about as difficult to learn and use as C++. To do something useful in Java takes time and effort. It also requires a level of programming skill that most Web page developers do not possess.

This is where JavaScript and VBScript enter the picture. As their names imply, they are scripting languages — like Macromedia Director's Lingo and Asymetrix Multimedia ToolBook's

## Programming for the World Wide Web With Java's Little Brother

OpenScript — rather than true programming languages. By definition, a scripting language is used within another application (HTML, in this case) to extend its capabilities. A scripting language is more limited than a stand-alone language like C++. This means you can't do as much in JavaScript as you can in Java. However, JavaScript (and VBScript) lets you easily include a wide range of interactive capabilities in Web documents.

The programs developed with JavaScript or VBScript are embedded within the file for an HTML document, like text or graphics. Both allow you to create programs to communicate with the user via message boxes, accept user input and evaluate it, perform common mathematical operations, manipulate strings, cause operations to be performed at specified times, and to display text in different ways (such as blinking text). In effect, JavaScript and VBScript turn HTML into a real programming language for the Web.

## About JavaScript

JavaScript did not begin life somewhere in Sun Microsystems, the originators of Java. Instead, it was originally developed by Netscape Communications as a scripting language for use with Web pages viewed with its Web browser. When Sun approached Netscape about using Java with the Netscape browser, Netscape decided, with Sun's blessings, to make its scripting lan-

guage conform to most of the major specifications and practices of Java. However, JavaScript is a clearly separate language than Java instead of a subset of it.

One big difference between Java and JavaScript is that Java is compiled while JavaScript is interpreted. Java programs exist as native code on a remote server, and that code is downloaded to your PC when you use a Java application. In contrast, the lines of JavaScript code are converted, line by line, by your PC into its native code. This has two big effects. A compiled program uses less memory than an interpreted program, so a JavaScript application will take longer to download than the same application written in Java.

Compiled programs are "ready to run" when downloaded, but interpreted programs must be converted into source code after being downloaded. This means a program written in Java will execute faster than the same program written in JavaScript. Another big difference is that JavaScript programs can only be run from within a HTML document. Java programs can be included within a HTML document or accessed from a HTML document, but Java programs are fully independent of HTML or a Web browser. If you were so inclined, you could distribute the executable file produced by a Java compiler on a floppy instead of the Web.

Since JavaScript programs are executed "inside" the Web browser, the Web browser must be able to interpret the JavaScript instructions. The Netscape 2.0 (and later versions) Web browser supports JavaScript, and Microsoft has included JavaScript support in its new Internet Explorer 3.0. Given the growing use of JavaScript on the Web, I expect the vast majority of Web users to be using JavaScript-enabled browsers by mid-1997. But to be safe, always place JavaScript programs inside HTML comment tags. Otherwise, all the lines of the JavaScript program will be displayed by a browser that doesn't support JavaScript. Not only will this be annoying to users, but you'll disclose your code to anyone who wants to copy it!

But don't forget the really big difference between Java and JavaScript: JavaScript is a heckuva lot easier to learn and use than Java!

JavaScript is object-based, but not object-oriented. This means JavaScript comes with a set of pre-defined objects for you to use, but your ability to define your own objects is limited (if you need to create custom objects, you really should use Java). The "top" object in a HTML/JavaScript file is the document. The next level down is the form. Each form can contain other objects. The third level of objects include buttons, check boxes, radio buttons, scrolling lists, text boxes, and various hyperlinks. JavaScript also includes features for math operations (finding square roots, generating random numbers, etc.), setting document colors, checking passwords for document access, keeping track of URLs visited, string manipulation, and other useful tasks.

Objects have "properties" and "methods" associated with them. The properties of a document object include its name, the color of its text, the color of its background, and lists of all forms and links contained in the document. You can set or alter an object's properties with JavaScript. Methods can be thought of as what an object is capable of doing. Among the methods of a document object are opening and closing of the document. Methods are activated through JavaScript.

JavaScript recognizes several user events, such as clicking on an object with the mouse, moving the mouse cursor over an area, or

# Software Wizardry

selecting text on a page. JavaScript lets you write "handlers" to respond to these user events.

JavaScript includes several control statements, including the while, for, if/else, break, and continue constructs. JavaScript has only one data type for variables, meaning you can stick integers, real numbers, or character strings into the same variable name. It also includes the usual math operational symbols (+, =, /, etc.) and relational (<, >, etc.) symbols.

## The Competition: VBScript

After the attack on Pearl Harbor, Japanese Admiral Yamamoto is reported to have said that he feared Japan had awakened a sleeping giant and filled it with a terrible resolve. In the case of the Web, Microsoft was the sleeping giant that received a wake-up call from Netscape and Sun.

When Netscape's Web browser and Sun's Java language exploded on the scene in 1995, Microsoft was caught flat-footed. However, Microsoft was no stranger to scripting and script-like languages. Its Visual Basic (discussed here a few columns ago) has always had strong similarities to a scripting language, and Visual Basic for Applications was the scripting language for such popular Windows applications as Word and

Excel. It was not surprising that Microsoft decided to go with a subset of Visual Basic for its scripting language.

Like JavaScript, VBScript is an interpreted language operating within a supporting Web browser. And that's where things get really interesting. Microsoft's Internet Explorer supports VBScript, and Microsoft has licensed JavaScript for use in updated versions of Explorer. At the time this was written, however, the more popular Netscape browser (including the newly released version 3.0) supports only JavaScript.

VBScript is based more upon functions than objects. In JavaScript, you use an object's methods to get something done, while in VBScript you use a function to do something to an object. VBScript uses far more of the built-in components of Windows, like message boxes, than does JavaScript. In fact, if you already are familiar with Visual Basic or Visual Basic for Applications, you already know most of the elements proposed for VBScript.

*Proposed for VBScript?* That's right! At the time this column was being written, Microsoft still had not finalized the exact functions and statements that would be part of VBScript. This discussion of VBScript is based on the latest beta of the VBScript specification; few (if any) changes

are expected in the final version.

Like JavaScript, VBScript has only one data type for variables that can be used to hold any type of data. (If you're familiar with Visual Basic, this is the variant data type.) VBScript includes a complete set of arithmetic, relational, and logical operators identical to those supplied in Visual Basic. Control statements include if/then/else, do/until/while, while/wend, and for/next. VBScript lets you write procedures and "subs" — independent sections of code referred to by name — that can be executed when needed. A procedure returns a value when executed, while a sub does not.

As befits a largely function-based language, VBScript includes a large number of functions for such tasks as math (calculating logarithms, square roots, exponentials, etc.), string manipulation and editing (for example, removing leading or trailing spaces from a string), data classification (determining if a variable has been initialized or contains an array), data conversion (converting a Boolean value into an integer, for example), and communicating with the user (displaying message boxes to get user input or to alert users of a situation). The latter functions use the same Visual Basic element codes that allow you to add different buttons (such as OK, cancel, yes, no,

## Is There Really A Future In Web-Based Computing?

Everybody hates Microsoft. Heck, even Bill Gates probably hates Microsoft too, although not as much as the executives at Sun, Oracle, Netscape, or other competitors. If you've read much about Java, Web-based computing, or proposed low-priced "network computers" that will only use software downloaded from the Web, one common theme runs through the publicity surrounding them: Web-based technologies will break Microsoft's grip on the software industry and finally put Bill Gates in his place.

I have no objection to putting Bill Gates and Microsoft in their places (wherever those places might be!). I understand why competitors hate Microsoft. But hatred is an emotion that blinds people, and even companies, to logic and common sense. It's easy to see why competing software companies would be delighted to see Web-based computing triumph, yet the only intelligent rationale for any business strategy is to offer things that customers are willing to pay for. By that standard, Web-based computing has quite a few problems that must be solved before it can be anything other than a pipe dream.

Let's start with an obvious problem: the Web is too slow to deliver anything big in a reasonable time frame. If you have a 28.8 modem, you have probably discovered that it seldom perks along at anything like that speed. Line noise is one big restraint, and an Internet link is only as fast as the slowest node between you and the server. Cable modems and other solutions (ISDN, etc.) offer real promise of speeding up things, but it will take some time before most Net nodes and servers are equipped for faster throughput. For the next three or four years — at least — the speed necessary for time-efficient delivery of software at a cost competitive with floppies, CD-ROMs, etc., just isn't going to be available.

Firms like Oracle have been promoting "network computers" (NCs) for Web-based computing. These systems will be low cost (under \$500.00) and designed to work strictly with the Web. (In fact, they won't even have a hard drive.) Even IBM, the same company that brought you the PCjr and the MicroChannel bus, has announced a \$700.00 NC without a floppy drive or hard disk. But is there a demand for NCs, and how practical would they be?

The price of fully configured Pentium multimedia PCs has now dropped to under \$1,000.00. Such PCs can access any Web-based application, plus can use software distributed on floppies and CD-ROMs — and you can create your own custom software using something like Visual Basic or Delphi. If you find interesting software or other materials (like audio or graphics files) on the Web with your PC, you can download and save them to your hard drive. That's not possible with a NC without a hard drive. Given the shrinking price differential between NCs and full-blown PCs, how many people will opt for a less expensive, but much less versatile NC?

I also have my doubts as to whether it's possible to achieve acceptable performance with an NC as cheap as \$500.00. All good software today has one thing in common: lots of memory (either in RAM or on a hard drive), is required. Take a look at the size of the files for any good word processor, spreadsheet, graphics, etc., applications program. Notice how often your hard drive has to do a "read" operation when using such applications. If such

software is delivered over the Web, how much RAM will an NC need? (The last time I checked, memory was much cheaper in magnetic rather than semiconductor form!) Unless we're talking about NCs with 64 megs of RAM (and then we're not talking about a \$500.00 NC!), a lot of "reads" and "writes" over the Web will be necessary . . . and that will take a lot of time with today's data transfer rates. Can you imagine the time it would take to spell-check a lengthy word processing document over the Web using a 28.8 modem?

Viruses are a big worry with any software obtained on-line. The developers of Java claim that it will be impossible for viruses to infect any software developed with Java, nor could anyone break into Java servers and databases. I certainly hope this is the case. However, I wouldn't bet my life on this being true. I have too much respect for the ingenuity of hackers.

Data security is another big issue. Let me put it this way: how comfortable are you at the prospect of having sensitive information — like your income tax returns, love letters to your boyfriend and/or girlfriend, confidential business documents, your medical records, etc. — residing on a distant server so they can be available to hackers or unscrupulous server administrators? Can you imagine what it would be like to discover someone had trashed your income tax records stored on a Web server? And Web and Net service providers have been known to go down without warning for hours, which could deny you access to your files at critical times.

How cheap will Web-based computing really be compared to existing PCs? In addition to Web access fees, it is likely that some sort of software "rental" fees will be imposed (how else will developers make any money?) and that data storage fees will be charged users by servers. Even if such charges are modest, they could quickly add up if you are a heavy PC user.

And let's don't forget mobile computing via notebook PCs. To have a Web-based notebook computer, you'd have to have some sort of built-in cellular telephone capability and cellular charges added in. And how practical would such units be in places where cellular telephones can't be used, such as aboard airplanes or inside some buildings?

In a way, Web-based computing makes me feel young again. It takes me back to the early 1970s, when I first got involved with computers and everyone used a dumb terminal connected by modem to a distant mainframe. The personal computer revolution was spurred in part by a desire to be free of the same problems — like data storage fees, security concerns, slow data transfer, access problems, etc. — that Web-based PCs have no answers for. And what are the real advantages of Web-based computing for average users instead of Microsoft's competitors? What could you do better in a Web-based computing environment than you could with existing PC technology? To be honest, I can't think of a single thing. Can you?

I think there is a big future in developing applets for Web pages, whether in JavaScript, VBScript, or Java. But the notion that Web-based computing is going to completely replace, or even significantly affect, the existing applications software business is daft. Anyone who claims differently is a fool, a liar, or both.

I can't wait to see the mail I get as a result of that last paragraph!

# Software Wizardry

and retry) to message boxes along with such graphics as stop signs, an exclamation point inside a triangular yellow sign, and a question mark inside a balloon.

Unlike JavaScript, you cannot create your own objects in VBScript. You can manipulate standard HTML objects like documents and buttons in VBScript, however. But VBScript does have one powerful advantage over JavaScript: it can use ActiveX controls.

## The Wild Card: ActiveX Controls

In a previous column, we looked at using "custom controls" in Windows programming. A control is just another way to refer to an object in Windows. Controls can be thought of as "software ICs" that can be plugged into the Windows "breadboard" that determines how objects communicate and interact with each other. Windows itself is nothing but a huge collection of controls. Controls range from the simple (a scroll bar) to complete spreadsheets and word processors. Controls can be developed with high-end Windows programming tools like Visual C++ and Delphi.

Controls were introduced in Windows 3.0, and 16-bit (.VBX) controls quickly became popular with programmers; 32-bit controls (.OCX) are used with Windows95/NT platforms and 32-bit versions of Visual Basic, Visual C++, Delphi, and other development tools. A thriving industry has grown up around creating custom controls. If you need a certain function — like a spinning text field or a password feature giving different levels of access to data — the odds are good that there is an .OCX control available to do the task. Instead of writing and debugging code, you can simply drop a custom control into a project just as easily as if you were adding a text field or button.

ActiveX controls are .OCX controls that can be used within VBScript. They are similar to applets developed with Java. However, there are a lot more .OCX controls out there than Java applets since .OCX controls can be used in any Windows95/NT application.

Microsoft's Internet Explorer 3.0 includes support for VBScript, JavaScript, Java applets, and ActiveX controls. Netscape's Navigator 3.0 includes support for JavaScript and Java applets, but not VBScript; support for ActiveX controls is an optional add-in.

Which leads us to ...

## Which is Better: JavaScript or VBScript?

In software, what is technically "better" is often irrelevant. It's especially so in this case, because JavaScript and VBScript are essentially identical in terms of their capabilities, ease of use, and time required to learn. It really comes down to a matter of personal preference on the technical side. If you've had some experience with C programming, you'll have a head start on mastering JavaScript. Likewise, if you know Visual Basic, you already know 90% of VBScript.

Whether you like it or not, what is "better" in software has more to do with market share and size of the user base than with technical merits. This means your decision should be made first and foremost on the basis of how many Web browsers can use the scripts you create.

Hands down, the current winner is JavaScript. The most recent versions of the Netscape and Microsoft browsers can run JavaScript, giving you the largest possible user base. There's no point in developing a cool Web page using VBScript if most users have browsers that cannot interpret the code!

But — hands down — the long term winner will be VBScript.

Microsoft is determined to win the "Web war" and is willing to do whatever it takes to win. How serious is Microsoft? If you want a copy of Netscape Navigator 3.0, you'll have to pay \$49.00. If you want a copy of Internet Explorer 3.0, you'll have to pay ... nothing. You can download a copy from Microsoft's Web site. It will come installed on Windows95/NT machines. Software developers can include it for free on their products. My company recently developed several CD-ROM titles that feature direct access to our Web site from the user interface. We decided to include a Web browser with each CD-ROM in case users didn't have one. We chose Internet Explorer for one reason: it was free while Netscape would have charged us.

While the first version of Internet Explorer

## Web Sites for More Information

<http://www.javasoft.com/java.sun.com>

If you want to learn more about Java or JavaScript, or order the Java developer's kit, this is the place to start.

<http://www.microsoft.com/ie/>

You can download a free copy of Microsoft's Internet Explorer browser from here.

<http://www.microsoft.com/intdev/>

<http://www.microsoft.com/ie/appdev/controls>

Microsoft makes ActiveX controls available at these two pages for you to download and use. Some that were available at the time this column was being written included various buttons, text boxes, scroll bars, pop-up menus, combo boxes, timers, and even a "ticker" to display data in a format similar to a stock market ticker tape.

<http://www.microsoft.com/vbscript>

Check here for latest news regarding VBScript.

<http://www.home.netscape.com>

Netscape's home page is where you can find out the latest about Netscape products, as well as download/purchase their software.

was lacking in comparison to Navigator, that's no longer the case; the consensus of beta reviewers of both Internet Explorer 3.0 and Navigator 2.0 is that neither has a real functional advantage over the other. Most reviewers seemed to prefer the Internet Explorer interface to the Navigator interface. The one real advantage Navigator has is that it will be available for Macintosh, OS/2, and Unix platforms in addition to Windows; Internet Explorer will be strictly Windows. However, Mac, OS/2, and Unix platforms are a small and diminishing chunk of total Web usage; Windows will clearly be the operating system for the vast majority of Web surfers.

Netscape is charging for its browser. Microsoft is giving its browser away, and will almost certainly incorporate a compatible browser in its next version of Windows. You don't have to be the proverbial rocket scientist to guess who will win this battle.

That's why I think that, long term, VBScript will win the war. Netscape will either change strategy (such as focusing on Web authoring or server software), add support for VBScript, or will go the way of VisiCorp and other former high-tech high flyers that came crashing to earth. Yeah, I don't like the idea of Microsoft dominating the Web either, but maybe we should just be thankful Bill Gates hasn't acquired nuclear weapons yet.

In the meantime, those who learn either JavaScript or VBScript will eat very well over the next few years! Future columns will be devoted to an in-depth look at each of these languages. NV

## How JavaScript and VBScript Differ

The crucial difference between JavaScript and VBScript is that JavaScript was designed to work across a wide range of hardware and software platforms, including Macintosh, OS/2, and Unix in addition to Windows. VBScript is designed strictly for Windows. This means VBScript can draw upon the pre-defined objects and functions of Windows for most tasks while JavaScript must define its own objects and functions independent of any operating system.

The following line of JavaScript code will display a dialog box with an "OK" button and the text contained within the parentheses:

```
alert("Hello, all you Nuts & Volts readers!")
```

To do the same in VBScript, this is the code you would use:

```
MsgBox("Hello, all you Nuts & Volts readers!", 0)
```

"alert" is a method by which a window object can display the specified text, while "MsgBox" is a standard Windows function — it's used by Visual C++ and other languages — that displays a dialog box with the indicated text (the

0 specifies that an "OK" button is to be included with the dialog box). This illustrates an essential difference mentioned in this month's column: JavaScript is largely based upon objects, their properties, and the methods by which objects do things, while VBScript is largely based on functions that do things to objects. The end result is often the same, but JavaScript and VBScript start from opposite directions to get there.

JavaScript methods are not available to all objects. For example, the fontcolor method (which sets text color) can only be used by string objects, and the open method (opens a new window) is only available to window objects. In VBScript, certain functions will work only with certain types of arguments. The function Sqr(7) will return a value of 49, since Sqr is the VBScript function to find the square of a number. The function Sqr("Hello!") will produce an error message because "Hello!" is a string, not a number.

Which approach is best? Academic and technical computing journals are filled with articles debating the virtues of object-based versus function-based computing. However, almost all JavaScript and VBScript programs are short and relatively simple, and the purported advantages (or disadvantages) of either approach will not be very noticeable in most situations. Your success in programming for the Web will depend less upon whether you choose JavaScript or VBScript, but instead more upon how well you use the language of your choice.

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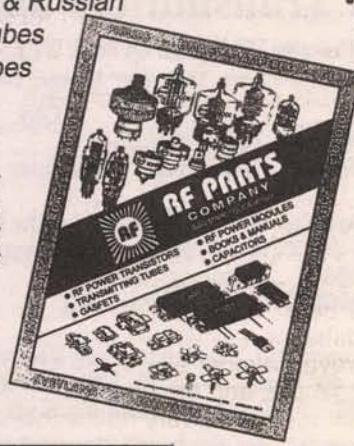
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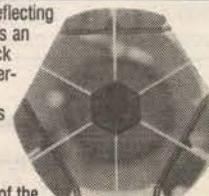


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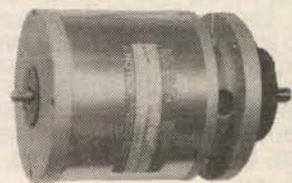
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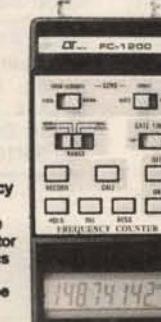
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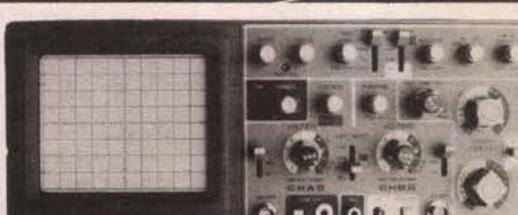
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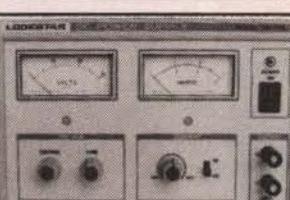


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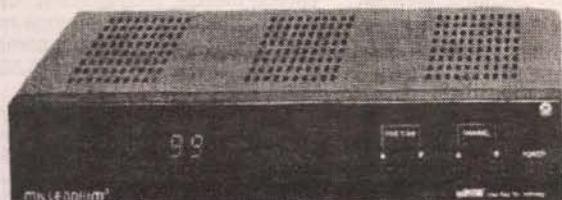
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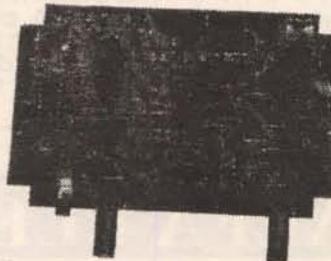
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# Holography 2

## Improving the Single Beam

by John Iovine

The Feb. '94 issue of *Nuts & Volts* (Vol. 15 No. 2) contains my first article on holography. The article featured how to shoot single beam white light reflection holograms. This article is a continuation of the first article with the purpose of improving the single beam holographic image.

The first article contained basic information on building a simple isolation table, exposing holographic plates, developing and viewing holograms. This information will not be repeated here. You will need this information to shoot the holograms outlined in this article.

If you don't have the first article, back issues are available from *Nuts & Volts*. Reprints may be available also.

### Overhead Lighting — Improving the Single Beam Set-Up

The single beam holographic set-up from the first article suffers from an obvious handicap: side lighting. To understand this, look at the spread beam of the laser to the holographic plate (see Figure 1). Where the spread laser beam first strikes the plate, labeled A, becomes the top of the plate.

The reason the "A" side becomes the top is that the light needed to reconstruct the holographic image must illuminate the finished hologram at the same angle the spread laser beam had during exposure. Figure 2 illustrates a typical display mounting. When the hologram is hung on a wall, with a point light source illuminating it at a 45-degree angle from above, the brightest image playback will be with the plate orientated so that holographic image appears on its side.

The impact this has on placing the model during exposure is important. Figure 3 illustrates. If the model is placed right side up when shooting the hologram with side lighting, when placed in the best viewing position on the

wall, the model will appear on its side. To correct this problem, the model must be placed on its side when shooting a hologram with side lighting, with the top of the model pointed toward the "A" side on the plate (see Figure 4). This places the holographic image of the model right side up when the plate is mounted in a stand or on a wall for viewing.

### Compensating for Side Lighting

Mounting models for side illumination can be accomplished in any number of ways. The model may be glued to a steel plate, and placed on its side using a magnet, as in Figure 5. Another simple method is to glue the object to a transparent piece of plastic and secure it to the table using binding clips and magnet, as in Figure 6.

You can use just about any type of glue that forms a strong bond. I use a two-part epoxy glue for permanent mounts, and a hot glue gun for semi-permanent or temporary mounts.

### Overhead Lighting, Method #1

#### Materials Needed

2 Front surface transfer mirrors  
1 10" long steel plate  
1 Jumbo magnet  
1 Radius mirror  
1 Holographic film plate with binding clip and magnet  
1 Model  
1 Shutter card

1 White alignment card  
1 Protractor

\* Note HeNe Laser and isolation table are required of all set-ups and are not included in the materials list.

We can get around the problem of side lighting by using overhead lighting. Overhead lighting allows one to record the hologram of the model in its proper orientation. With overhead lighting, the laser light strikes the plate at a 45-degree angle (see Figure 7). For overhead lighting, you need a few more components: two front surface (FS) mirrors, one 10" x 1" x 1/16" steel plate, and one jumbo magnet.

The first FS mirror reflects the laser at a 45-degree angle. The second FS mirror reflects the laser up toward the radius mirror that is mounted on top of the 10" steel plate. The jumbo magnet secures the longer steel plate to the table. The radius mirror reflects and spreads the laser beam down to the holographic plate. The model is placed right side up behind the plate.

To check the plate position, use either a dummy glass plate or a white alignment card cut to the same size as a holographic plate. Make sure the spread beam completely covers the holographic plate.

### Checking the Angle

Use a protractor to check the angle of the incident beam. It is easy to misjudge the angle by eye. Figure 8 shows a protractor set for a 45-degree angle. You can use a beam angle between 30-45 degrees. If the spread beam doesn't completely cover the plate, you can move the radius mirror up a little, or move the plate position a little further away. Moving the plate will change the angle, but as long as you are in between 30-45 degrees, you will be okay.

### Loading the Holographic Plate

Turn off all standard room illumination. Turn on your safe light. Shutter the laser with the shutter card. Remove a fresh holographic plate and load it into position.

### Exposure Time

Assuming you are using a radius mirror with the laser

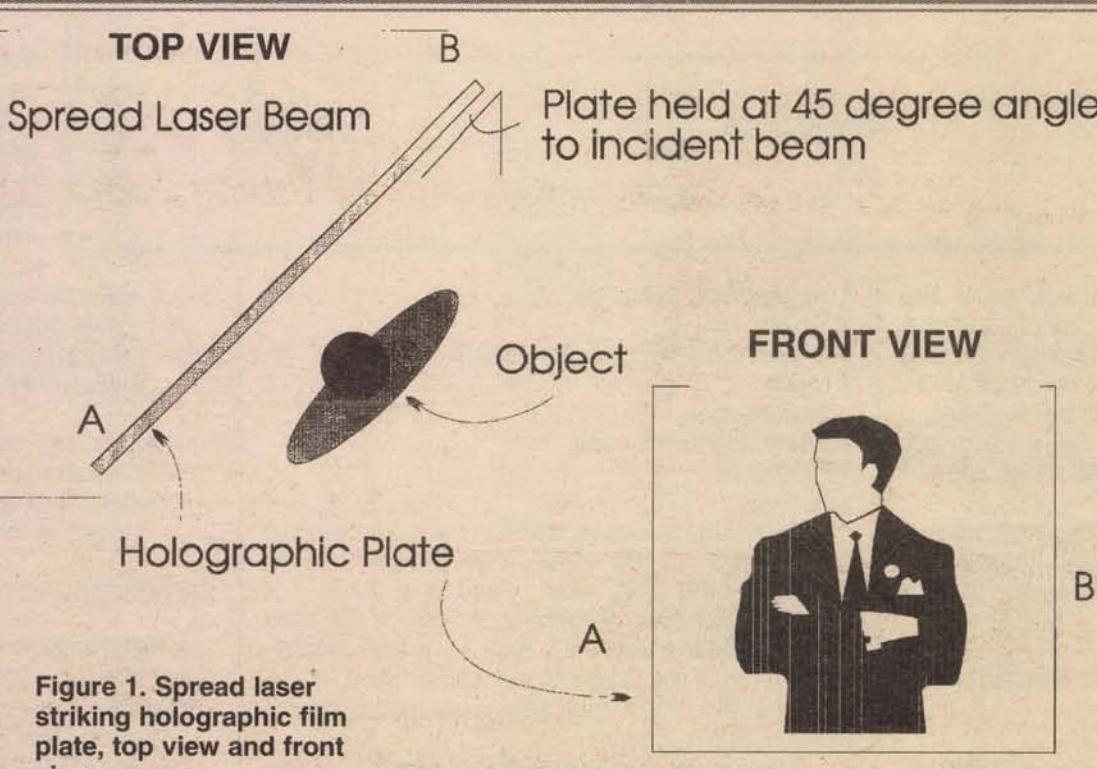


Figure 1. Spread laser striking holographic film plate, top view and front view.

beam spread to a diameter of approximately three inches, use the following exposure times as a start:

1 milliwatt laser	6 seconds
1.25 milliwatt laser	5 seconds
2.5 milliwatt laser	3 seconds
5 milliwatt laser	1.5 seconds

If you are using the steel spherical mirror, double the exposure times. To determine the best exposure time for your hologram, you will need to make a test exposure strip.

and 10. The holographic plate is supported off the table above the model using magnets. This arrangement provides excellent stability for the holographic plate and model.

#### Materials Needed

- 2 Front surface transfer mirrors
- 1 10" long steel plate
- 1 Jumbo magnet
- 1 Radius mirror

comfortably on the magnet tops. Place a white alignment card on top of the magnets and direct the spread beam from the radius mirror onto the card. Align the beam so that the card is evenly lit with laser light.

To secure the glass holographic plate to the magnet tops, make three small balls (3/16

#### Spotlight

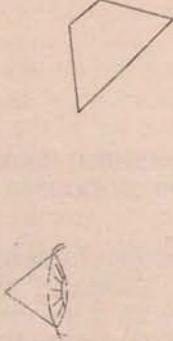


Figure 2. Spot light illuminating a hung hologram.



#### Development

Develop and view the hologram as described in the first article.

#### Improving the Hologram

When laser light strikes the holographic plate, the edges of the glass holographic plate deflect some of the incident light, creating a slight degradation (diffraction) in the finished hologram. This degradation is seen as a slight rainbow effect in the hologram caused by the recording of the diffracted light and the reference beam (and/or object beam).

To prevent this from happening, paint the edges of the holographic plate black using a permanent ink black magic marker. During development, some of the ink may come off in the solution, making little black floaters in the solution. So far these floaters have not caused me any development problems, and the solutions are still reusable.

Painting the edges of the glass holographic plates black before shooting will also improve the quality of all holograms, regardless of the particular set-up.

#### Improving Model and Plate Stability with Overhead Lighting

Using the overhead lighting, it is possible to lay the model flat onto the table. See Figures 9

Figure 3. Shooting side illumination with model right side up and impact on viewing resulting hologram.

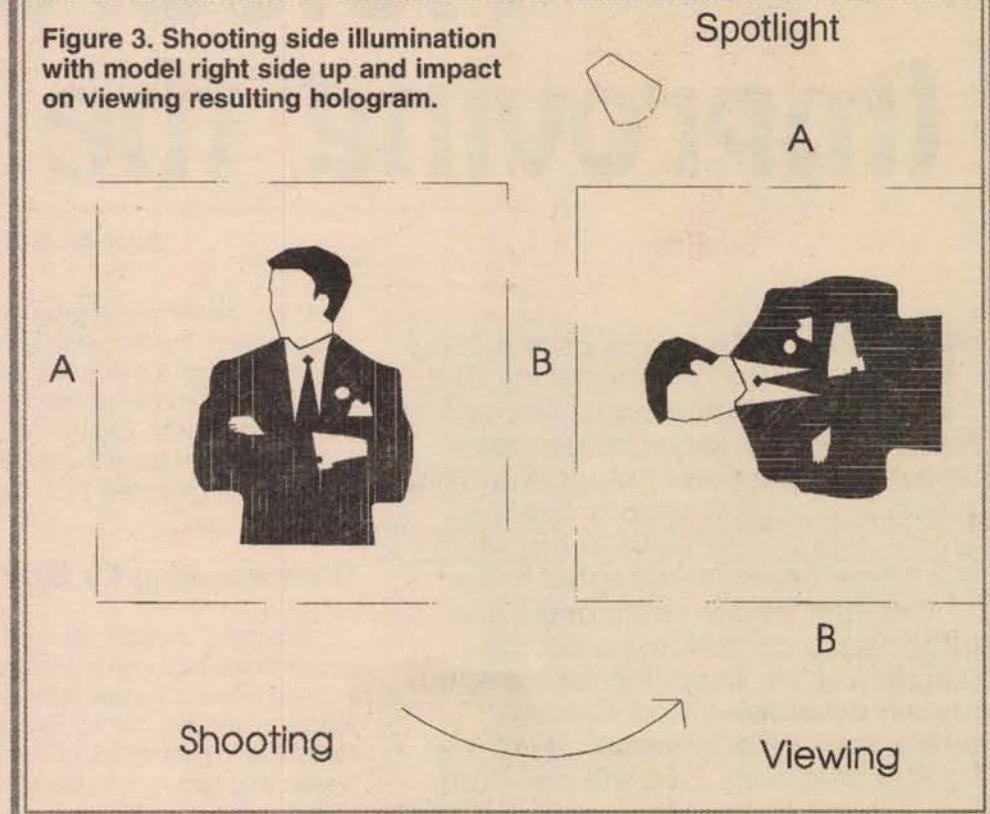
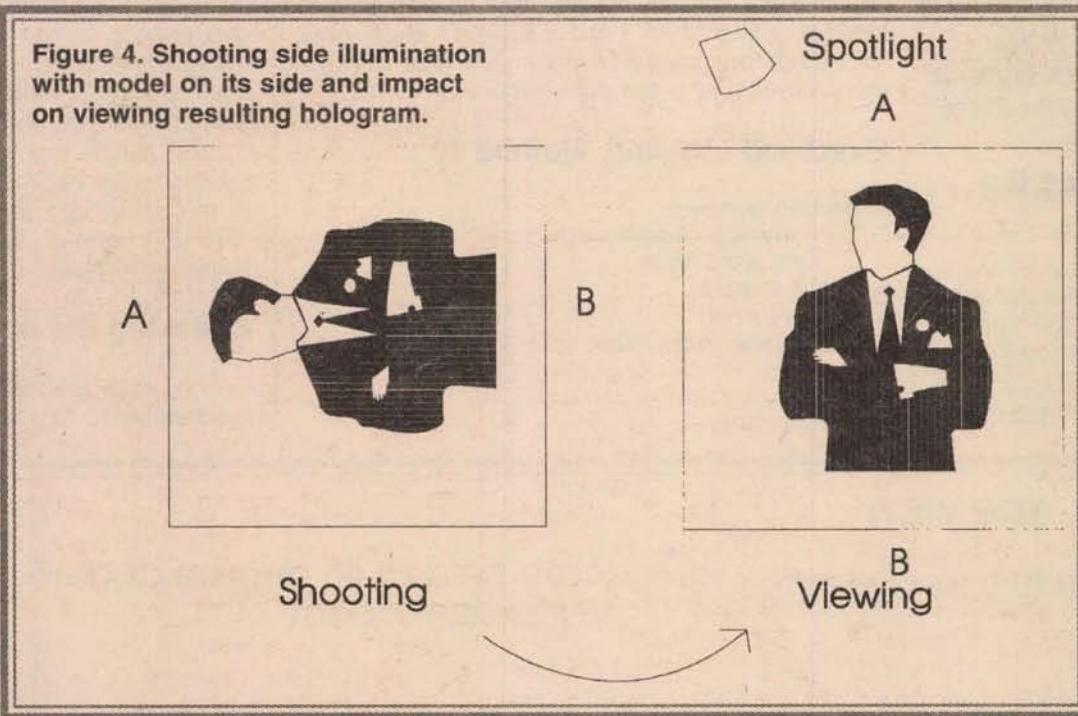


Figure 4. Shooting side illumination with model on its side and impact on viewing resulting hologram.



- 1 Holographic film plate
- 3 Square magnets
- 1 Clay or Fun-Tak (small amount)
- 1 Model
- 1 Shutter card
- 1 White alignment card
- 1 Protractor

To insure maximum stability, the model should be secured to the table. The model can be secured to the table in any number of ways. For instance, hot glue a magnet to the model then secured it to the table. Hot glue the model directly to the table. If the model has some weight to it, the weight of the object itself will insure that it doesn't move during exposure.

Position the three magnets around the model. Use a dummy plate to check that the plate will rest

diameter) of clay and place them on top of the magnets where the holographic plate touches the magnets. See Figure 11. When loading the plate onto the assembly, place the plate onto the clay balls and press down firmly, squashing the clay flat as in Figure 12. Do not re-adjust the holographic plate or it will not be secure. If the plate must be re-adjusted, remove it from the magnets, taking care to remove all the clay. Re-ball the clay and place it back onto the magnets and place the plate down again.

#### Exposure Times

Assuming you are using a radius mirror with the laser beam spread to a diameter of approximately three inches, use the following exposure times as a start:

1 milliwatt laser	6 seconds
1.25 milliwatt laser	5 seconds
2.5 milliwatt laser	3 seconds
5 milliwatt laser	1.5 seconds

If you are using the steel spherical mirror, double the exposure times.

Expose the hologram using the shutter card as described in the previous article.

#### Development

REMEMBER to remove all the clay from the plate before processing! Develop and view the hologram as described in the previous article.

When using single beam overhead lighting, this is the preferred method to use. Note that the top of the plate is facing the overhead lighting.

## Model

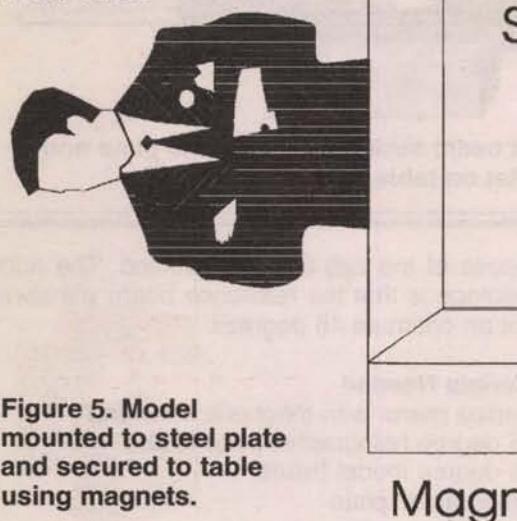


Figure 5. Model mounted to steel plate and secured to table using magnets.

## Steel Plate

## Magnet

becomes the second side.

I made the top of the fixture out of some copper clad board I had lying around. Its size is 6" x 4-7/8". You can use just about any rigid material, for instance, 3/16" plywood, (1-8/1-4") plastic or 3/32" sheet metal.

A channel is cut out of the top piece of the fixture. The width of the channel is made a little smaller than the plate it needs to hold, in this case, approximately 2.25 inches (to hold 2.5" square holographic plate). When the holographic plate is placed in the fixture channel, each side of the plate will be supported by a 1/8" lip. The overall channel size is 2-1/4" wide by 3-1/2" deep.

The bottom plate of the fixture is needed to make the fixture rigid and strong. I also made this out of some copper clad board. Its overall size is 3.5" x 6".

were using the fixture for was to hold a plate for making holograms, that would be fine. To use the fixture for making image plane copies, a thicker channel is more desirable, you will see why later.

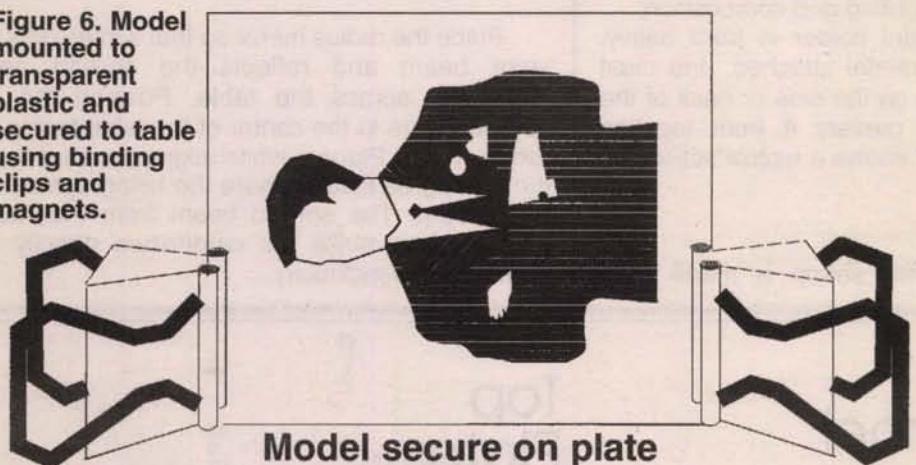
Make sure you can place a plate in and out of the U channel easily. Don't position the wood so close that it binds the plate in, this will create problems. Figure 14 is a photo of the completed fixture.

## Model Fixture

The holographic plate fixture holds the plate at a 45-degree angle to the incident beam. If we placed our model up-right behind the plate, the top of the model will be further from the plate than the bottom. When viewing the finished hologram, it would appear as if our model were leaning back. In addition, the bottom of the model would be brighter and in clearer focus because of its closer proximity to the plate, while the top of the model will be duller and less focussed due to its distance from the plate.

To correct this, we need a simple model fixture that will hold the model at a 45-degree angle. With the model held at a 45-degree angle, it would be parallel to the holographic plate and the entire

Figure 6. Model mounted to transparent plastic and secured to table using binding clips and magnets.



## Model secure on plate

fixture. To prevent any diffraction degradation from the edge of the holographic plate, you should paint the edges of the holographic plate black.

## Overhead Lighting, Method #2

Another way to achieve overhead lighting is to use side lighting and tilt the holographic plate towards the spread laser beam at an angle of 45 degrees. This allows one to use the side lighting set-up and trick the plate into seeing an overhead light. To perform this function easily and accurately with minimum fuss, it is best to make a small fixture.

The fixture allows one to quickly set up a simple reflection hologram set-up with an optimal reference beam angle.

## Fixture

The fixture, illustrated in Figure 13, is multi-purpose. It can be used to create holograms as well as make image plane reflection copies.

The sides of the fixture are made from 1 x 4 inch lumber. Lumber is usually a little smaller than the size it is called. For instance, 1 x 4 lumber's actual size is 3/4" thick by 3-1/2". Cut one end of the lumber at a 45-degree angle. This cut can be made accurately using a miter box. A miter box has slots to fit a saw for standard angles, as well as straight cuts.

The piece you first cut is the first side. Now use a straight cut to remove the 45-degree angle that is left on the original piece of wood. This

The top and bottom plates are secured to the side using small wood screws. Drill holes in the top and bottom plates for the screws. Use these holes to mark the hole positions on the sides with a pencil. Drill small pilot holes for the wood screws to prevent splitting the wood.

The outer channel on the top section is made out of three pieces of 1/2" x 3/4" wood. Each piece of wood is a side of the "U" channel. The wood is secured to the top plate using hot glue. If you have a discarded holographic plate from a previous attempt, place it on top of the channel so that there is 1/8" lip on each side and the bottom. Next, position the 1/2" x 3/4" wood next to the glass plate on the top plate and glue it into place.

The 1/2" side of the wood is glued to the surface leaving the 3/4" side protruding up. You may question why we are using such a large thickness of wood to hold the holographic plate in position. We could just as easily use a 1/8" thick piece of material. If the only thing we

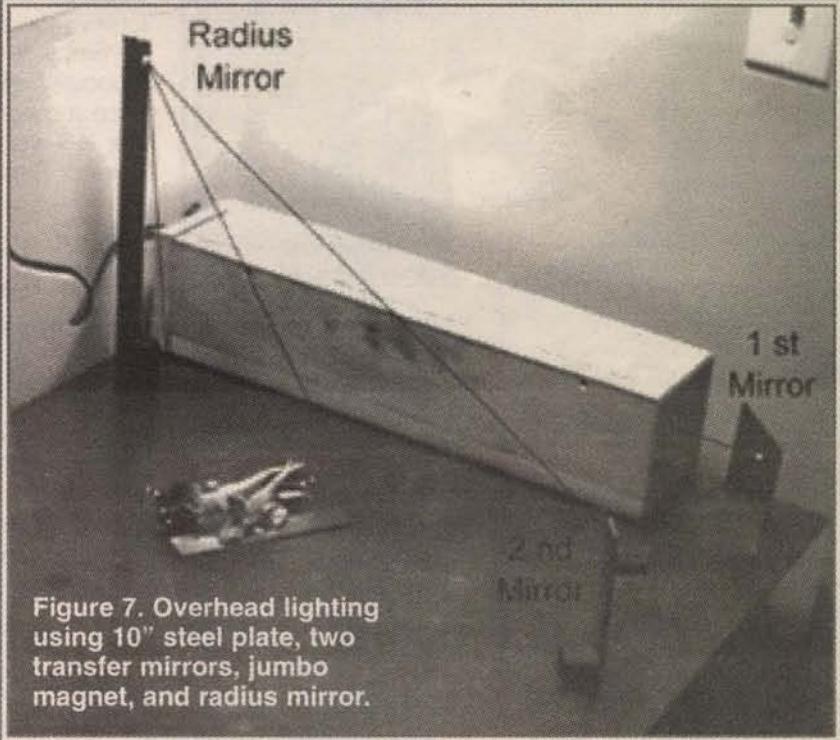


Figure 7. Overhead lighting using 10" steel plate, two transfer mirrors, jumbo magnet, and radius mirror.

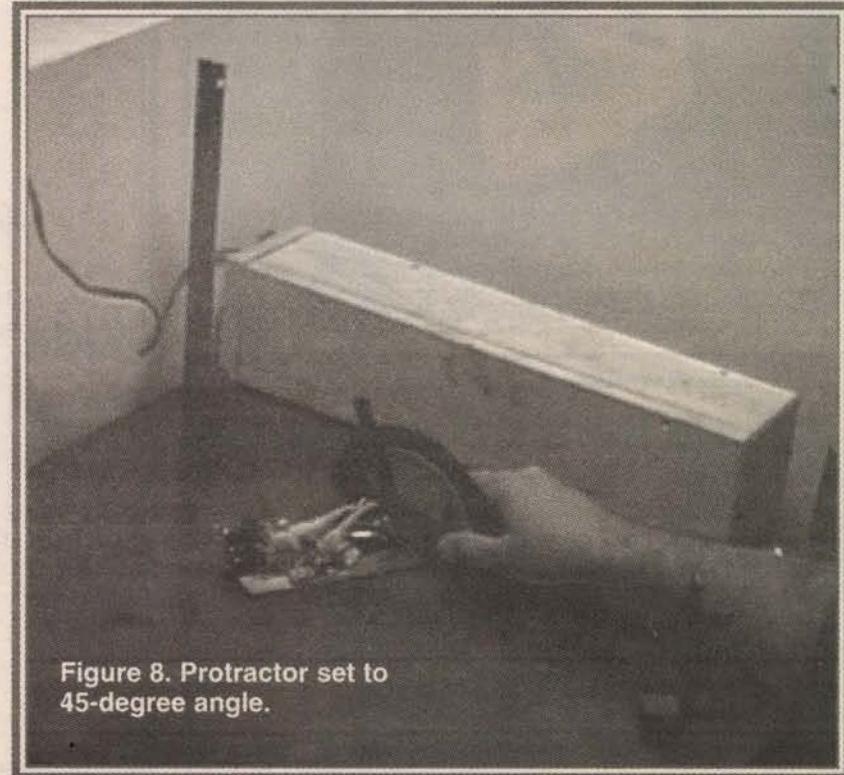


Figure 8. Protractor set to 45-degree angle.

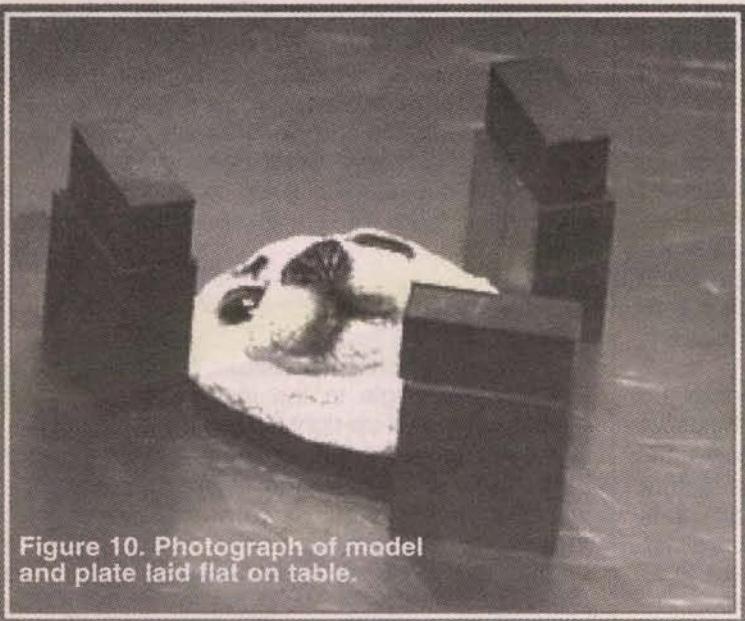


Figure 10. Photograph of model and plate laid flat on table.

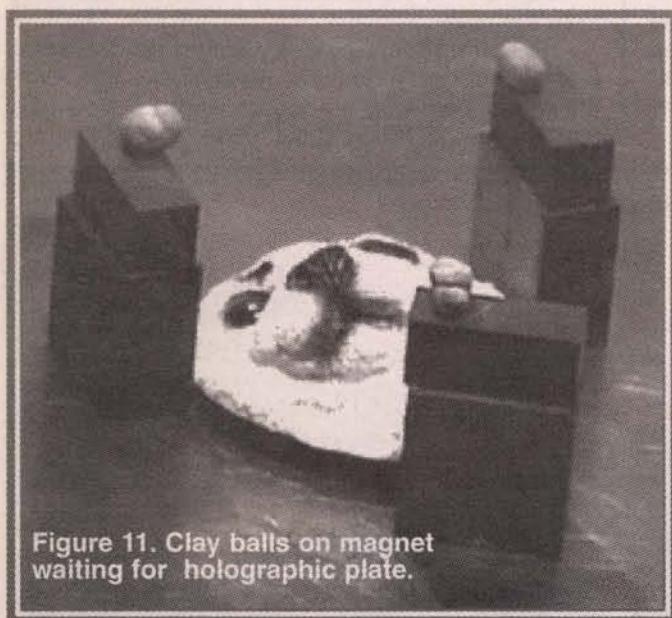


Figure 11. Clay balls on magnet waiting for holographic plate.

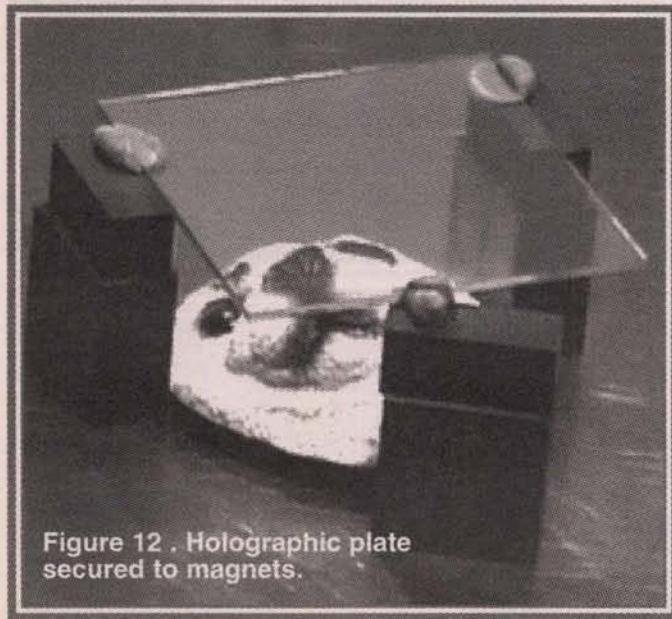


Figure 12 . Holographic plate secured to magnets.

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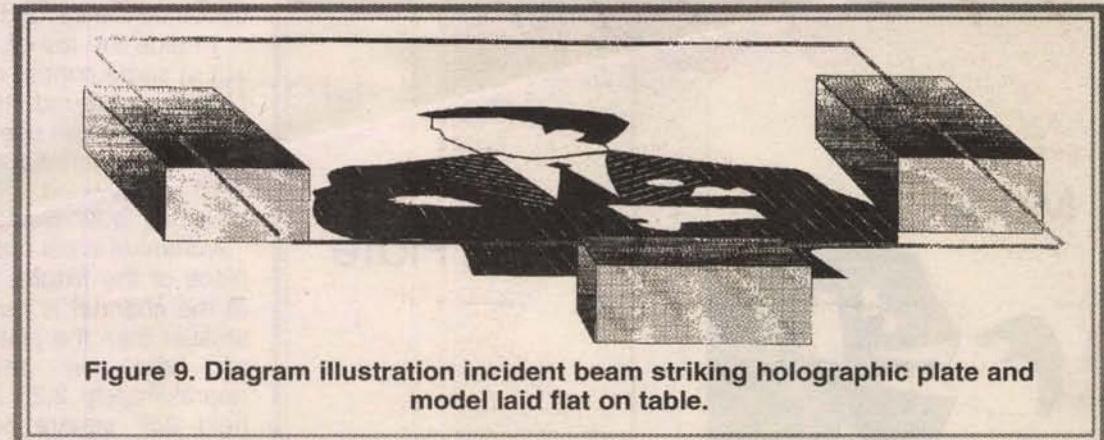


Figure 9. Diagram illustration incident beam striking holographic plate and model laid flat on table.

model will holograph much clearer.

The model holder is a piece of 1 x 4 lumber with a 45-degree angle (see Figures 15 and 16). You have the option of attaching models directly to the model holder. I glued a strip of 1" x 5" x 1/16" thick steel plate to the front. Next, glue a strong magnet to the model you will holograph. The models are held to the steel strip on the model holder using the magnet. This arrangement allows one to move the model up and down and angle it left or right to achieve the best lighting and composition.

Since the model holder is front heavy, especially with a model attached, one must place a magnet(s) on the side or back of the 1 x 4" wood to prevent it from toppling forward. Figure 17 shows a typical set-up.

#### Set-Up

This holographic set-up is made easy

because of the two fixtures involved. The added advantage is that the reference beam will always be at an optimum 45 degrees.

#### Materials Needed

- 1 Radius mirror with magnetic mounting
- 1 45 degree holographic plate fixture
- 1 45 degree model fixture
- 1 Holographic plate
- 1 Model
- 1 White alignment card
- 1 Black shutter card

Place the radius mirror so that it intercepts the laser beam and reflects the spread beam diagonally across the table. Position the 45-degree fixture in the center of the table facing the radius mirror. Place a white alignment card inside the 45-degree fixture where the holographic plate will be put. The spread beam from the radius mirror should strike the card/fixtures directly (90 degrees perpendicular).

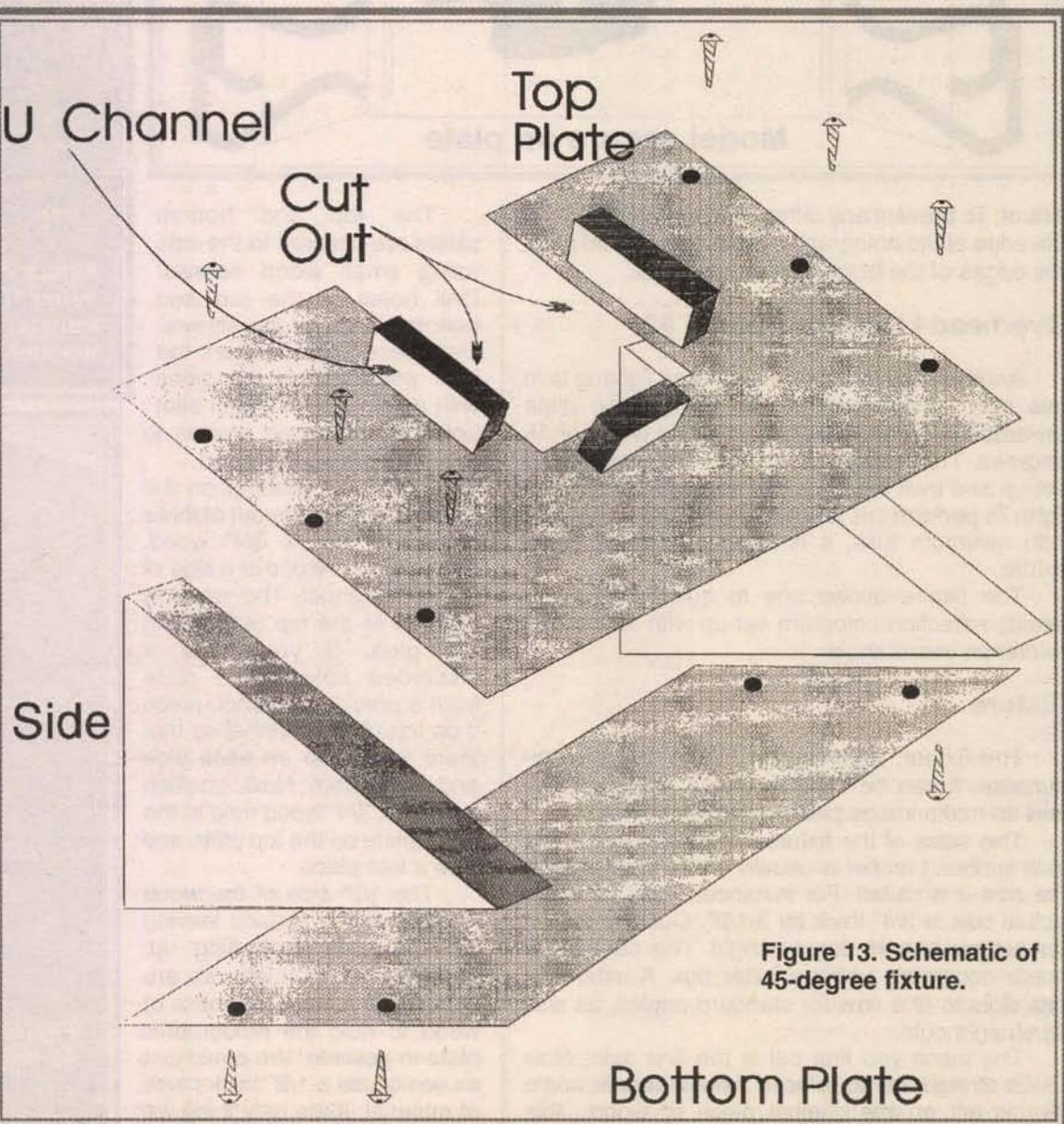


Figure 13. Schematic of 45-degree fixture.

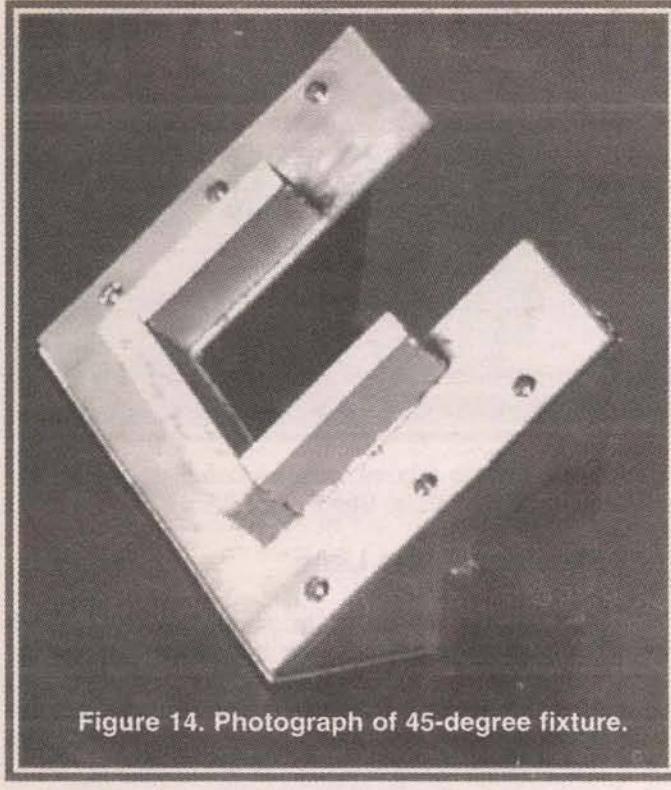


Figure 14. Photograph of 45-degree fixture.

Align the radius mirror so that a clean spread beam evenly illuminates the white alignment card. If the spread beam doesn't cover the card completely, move the fixture further away until it does.

Replace the white alignment card with a dummy glass plate. Position the model as close to the plate as possible. Remove the dummy plate, turn on the safe lights, and turn off any standard room lights. Shutter the laser.

### Exposure Times

If you are using a radius mirror with the laser beam spread to a diameter of approximately three inches, use the following exposure times as a start:

1 milliwatt laser	6 seconds
1.25 milliwatt laser	5 seconds
2.5 milliwatt laser	3 seconds
5 milliwatt laser	1.5 seconds

If you are using the steel spherical mirror, double the exposure times. Expose the hologram using the shutter card as described in the previous article.

### Development

Develop and view the hologram as described in the previous article.

Why use side lighting if overhead lighting is better?

As we continue, we will be using a lens to collimate the reference beam. To maximize component stability, it is easier to have the components lay flat on the table using side lighting rather than overhead lighting. In addition, it is easier to match the path distances with a beam that is parallel to the table. All this will become evident when we cover those procedures later on.

### Light Losses and Minimum Components

Each time the laser beam is reflected from an FS mirror, a small amount of light intensity

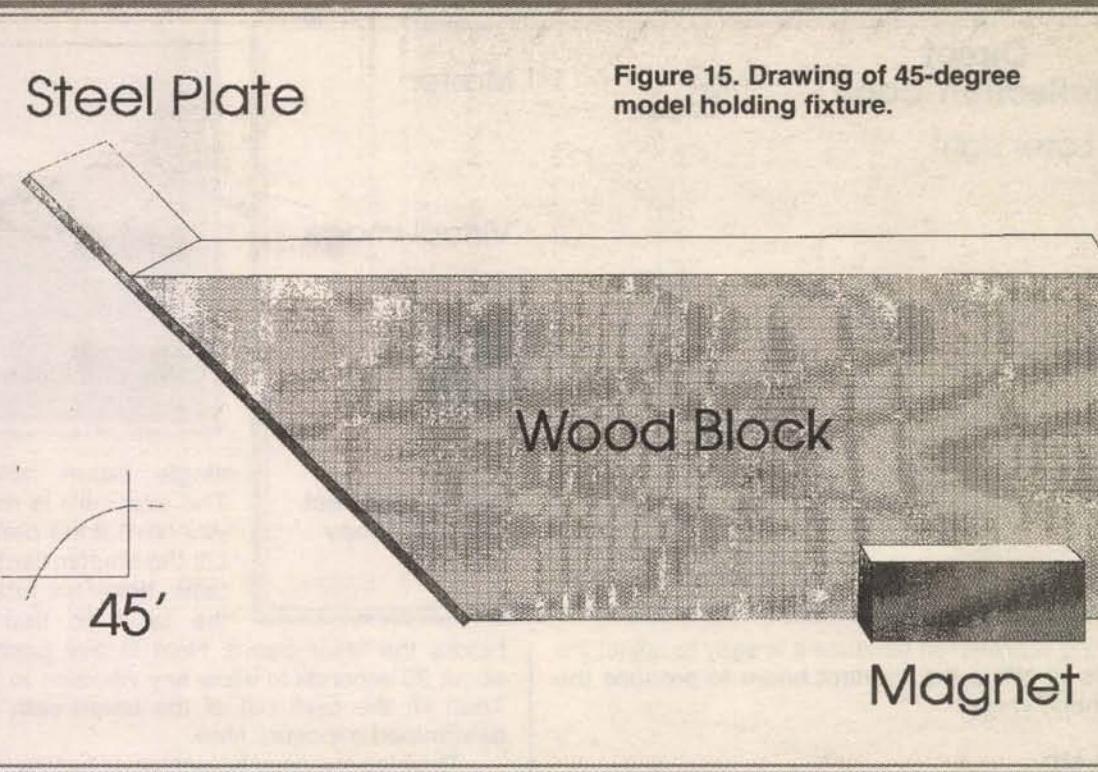


Figure 15. Drawing of 45-degree model holding fixture.

(approximately 8%) is lost. The simple arrangement used for overhead lighting for single beam reflection uses three reflecting surfaces. This doesn't have too much impact on the exposure time. However, when working with complex split beam set-ups, the amount of mirrors in each beam path can add up, requiring a longer exposure time than what you may have originally estimated.

One should always strive to minimize the components used on the table. Aside from the light losses, each component used brings with it its own risk that it may move or

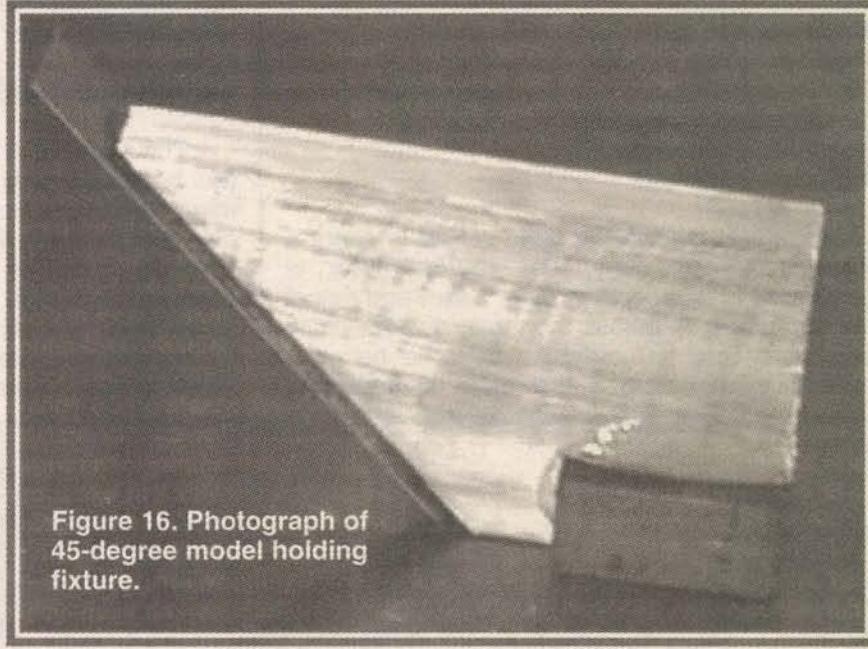


Figure 16. Photograph of 45-degree model holding fixture.

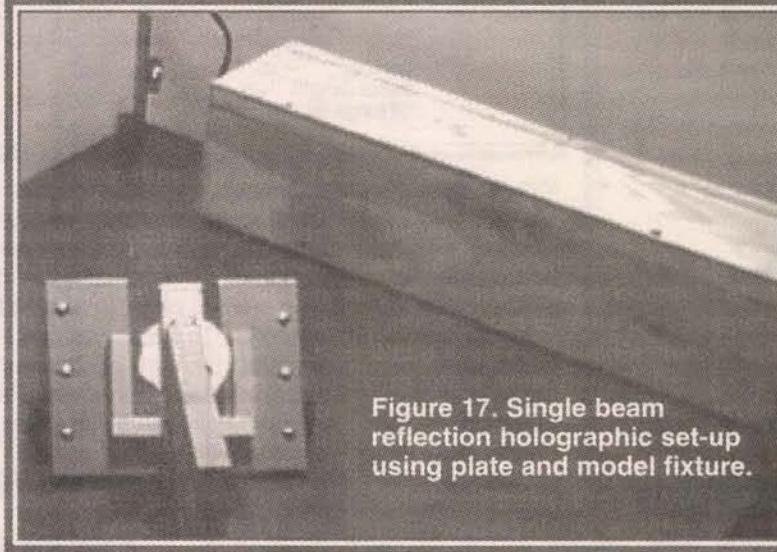


Figure 17. Single beam reflection holographic set-up using plate and model fixture.

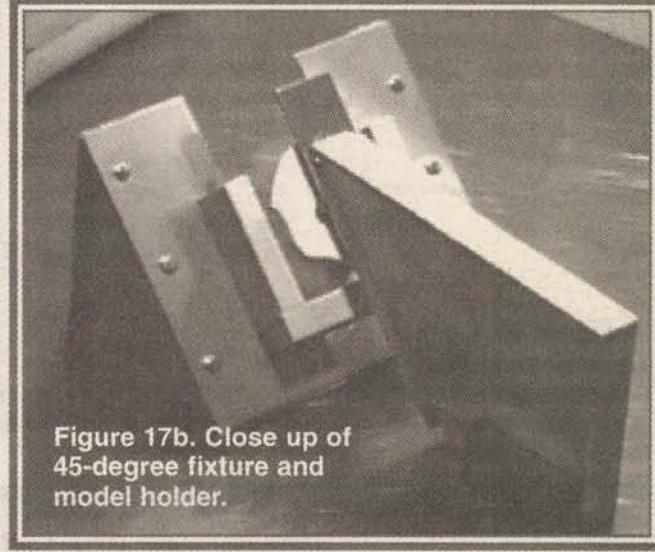


Figure 17b. Close up of 45-degree fixture and model holder.

become misaligned at the last moment, ruining a potentially good hologram. So, if you do without a particular component on the table, do so.

### Direct Reflection Copies

Suppose you've shot a hologram that came out very nice. You show it around to your friends and someone asks you to make them a copy. Well you could set-up the table again and re-shoot, or you could make a direct reflection copy.

The standard notation for the master hologram (the one you are making a copy of) on an illustration, diagram, or schematic is H1. When you see a plate labeled H2, that is the standard notation for the copy plate.

Making reflection copies is easy. Figure 18 illustrates the basic set-up. H1 is placed in the spread beam, angled to produce the brightest image. Two magnets and one clip on each side of H1 are used to secure the H1 plate in the proper position and angle. In this particular case, side

## Direct Reflection Copy

Laser Light

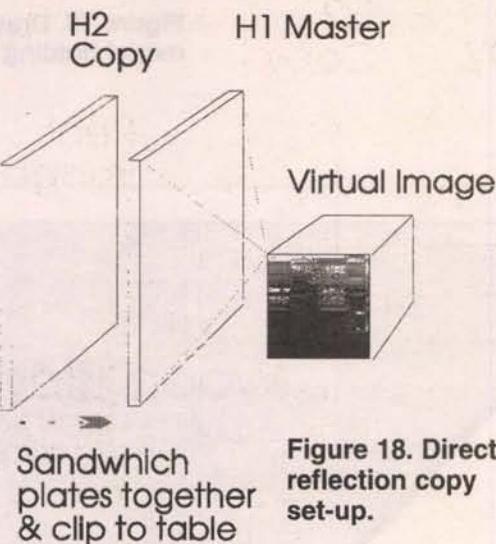


Figure 18. Direct reflection copy set-up.

lighting is preferred because it is easy to adjust the angle of H1 to the incident beam to produce the brightest image.

### Set-Up

#### Materials Needed

- 1 Radius mirror
- 1 H1 hologram
- 1 Holographic plate (H2)
- 1 White alignment card
- 1 Black shutter card

Figure 19 shows the table set-up to shoot a direct reflection copy. The radius mirror is positioned to intercept the laser beam and reflect the spread beam across the table. Use the white alignment card to determine that the beam is spread evenly across the plate without any

blocks the laser beam. Hold in this position for about 30 seconds to allow any vibration to die out. Then lift the card out of the beam path for the determined exposure time.

Develop the copy hologram as before. When it has dried completely, you should have an exact copy of the original.

### Collimated Reference Beam

The laser light we have been using thus far has been diverging sharply from a lens or radius mirror. In many cases, it is preferred to use a collimated beam. What is a collimated beam? When a beam is collimated, it is no longer diverging outwardly into space, rather the beam stays the same size, traveling roughly parallel through space. No collimation is perfect. The traveling light beam will eventually diverge, but

single beam hologram. The exposure is made as you have done previously. Lift the shutter card off the table, holding it just above the table so that it still covers a point where it completely covers a holographic plate. See Figure 22.

### Setting Up the Lens

Set up the table to shoot a single beam reflection hologram, using the 45-degree fixture. Begin by placing the radius mirror on the table so that it intercepts the laser beam and reflects the spread beam diagonally across the table. Place the collimating lens in front of the diverging beam. If you know the focal length of the lens, place it at that distance from the diverging optic.

Always check the resulting beam to make sure it is collimated. An easy way to check it is to hold a white card behind the lens. Move the card toward the lens and back away from the lens. The outline of light shining on the white card should remain the same (not get bigger or smaller). If it does, the lens is not in the proper position. Move it toward or away from the diverging optic and check it again. When the outline stays completely stable, continue setting up the table.

Place the fixture on the table so that the collimated beam will illuminate the holographic



Figure 19. Direct reflection copy table set-up.

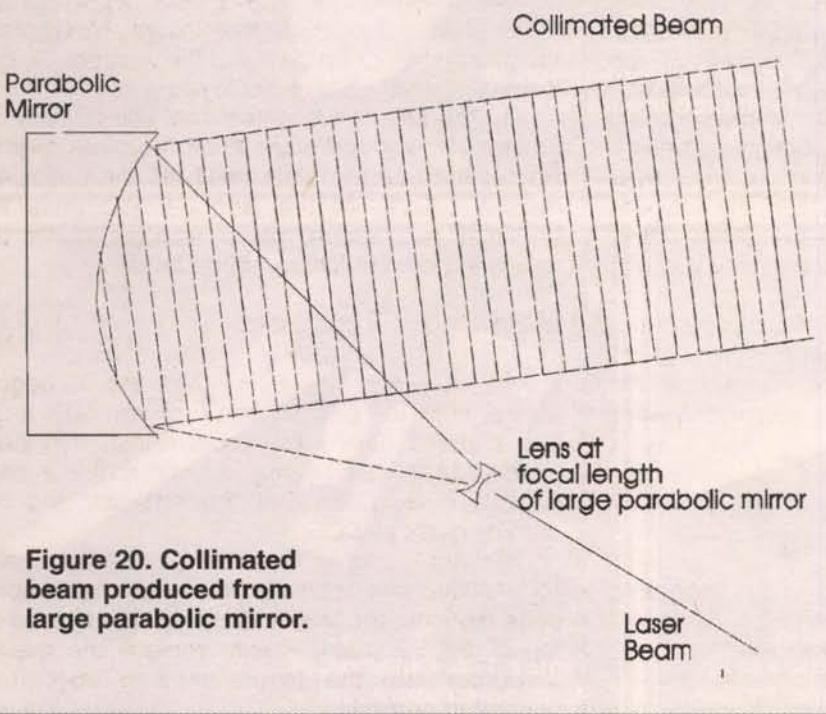


Figure 20. Collimated beam produced from large parabolic mirror.

imperfections. Remove the white alignment card and position the H1 hologram at this position. Angle the H1 hologram in the spread laser beam to the angle that produces the brightest image. Secure the position by using a binding clip and magnet on each side of H1.

Block the laser with the shutter card. Turn on the safelight(s) and turn off all standard room illumination. Take out a fresh holographic plate (H2) and sandwich it in front of H1 using the two binding clips.

Typically the exposure time to make a copy is around the same exposure time used to make a

this is not a concern for us. On the isolation table, for all intents and purposes, the beam can be considered perfectly collimated.

There are a few methods open to us for collimating the laser light. One method uses a large parabolic mirror similar to the small radius mirror, only much larger. By placing a diverging optic (radius mirror, negative lens, or positive lens) at the focal point of the large parabolic mirror, the light reflected from the large mirror becomes collimated (see Figure 20).

Another method, and the one we will use, is to use a positive lens, as in Figure 21. The positive lens may be a plano convex or double convex. Since the holographic plates we are using are 2.5" square, we can get away with using a lens that is a little bigger than the plate itself.

The main consideration in choosing a lens is that the focal length (FL) of the lens be long enough so that the radius mirror has spread the

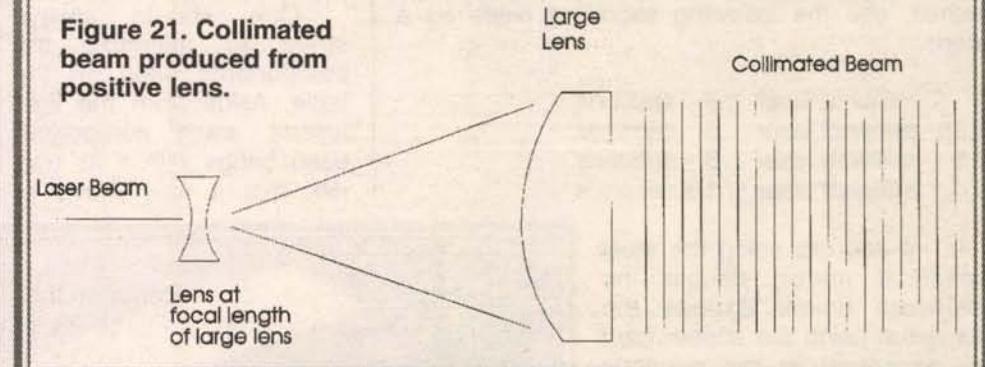


Figure 21. Collimated beam produced from positive lens.

plate. Place a white alignment card into the 45-degree fixture. Check the spread beam to insure that it is covering the card completely. Remove the white alignment card and place a dummy glass plate in the fixture. Place the model behind the plate position. Remove the dummy glass plate. Turn on the safe light and turn off standard room illumination. Shutter the laser and load the fixture with fresh plate.

### Exposure Times

If you are using a radius mirror with the laser beam spread to a diameter of approximately three inches, use the following exposure times as a start:

1	milliwatt laser	6	seconds
1.25	milliwatt laser	5	seconds
2.5	milliwatt laser	3	seconds
5	milliwatt laser	1.5	seconds

If you are using the steel spherical mirror, double the exposure times. Expose the hologram using the shutter card as described previously.

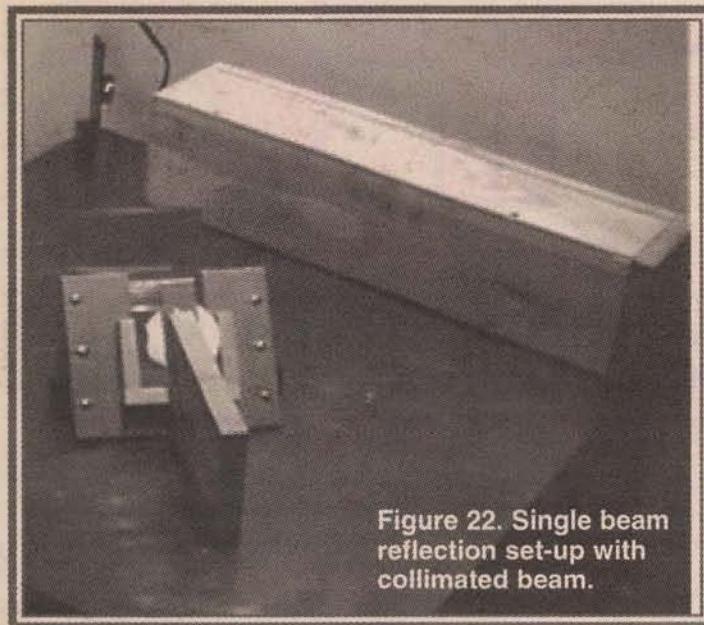


Figure 22. Single beam reflection set-up with collimated beam.

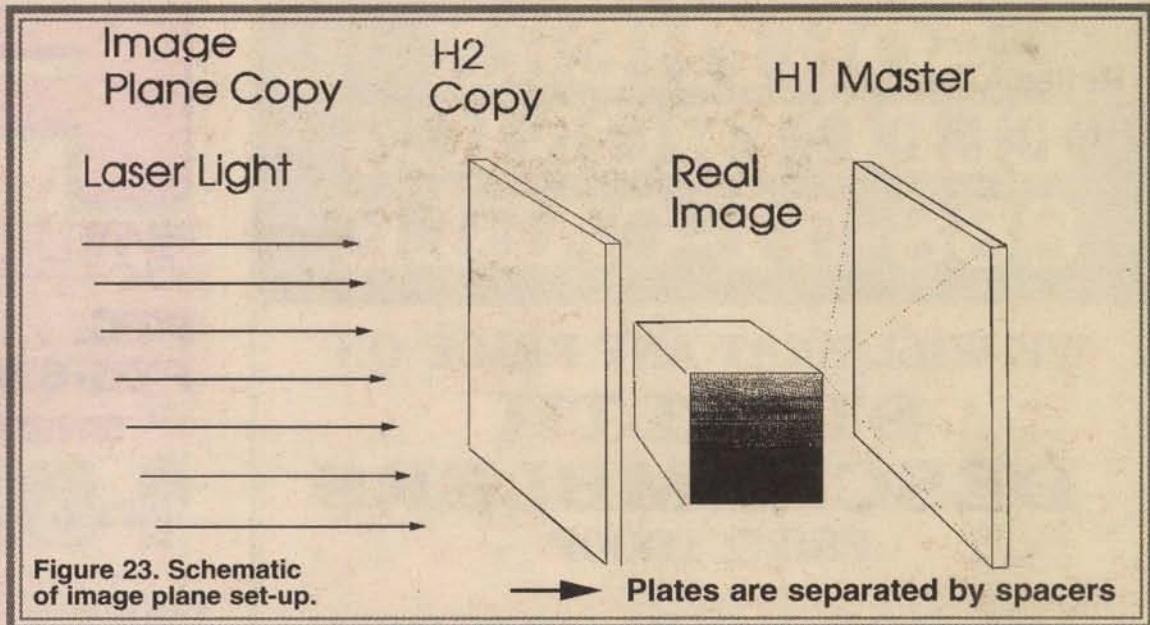


Figure 23. Schematic of image plane set-up.

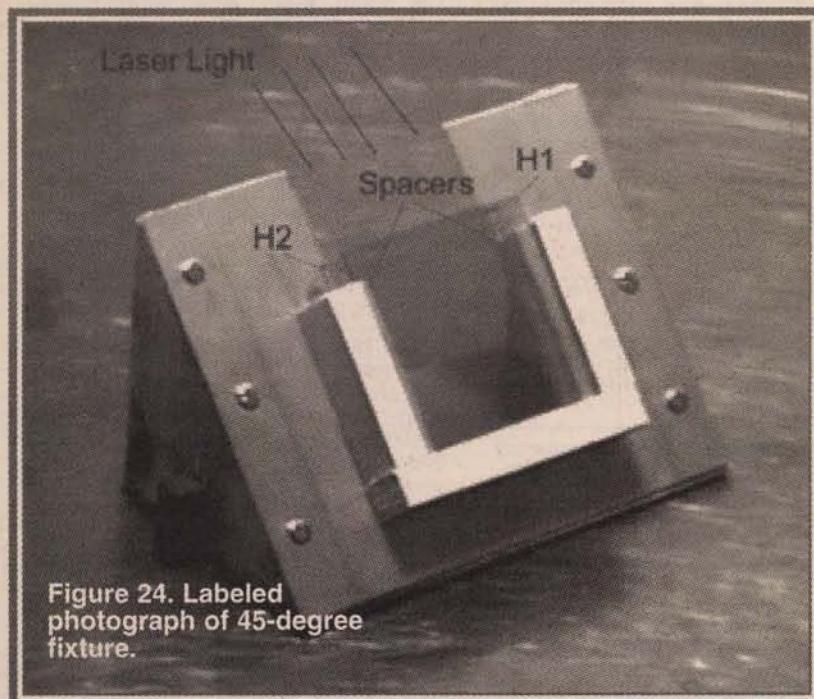


Figure 24. Labeled photograph of 45-degree fixture.

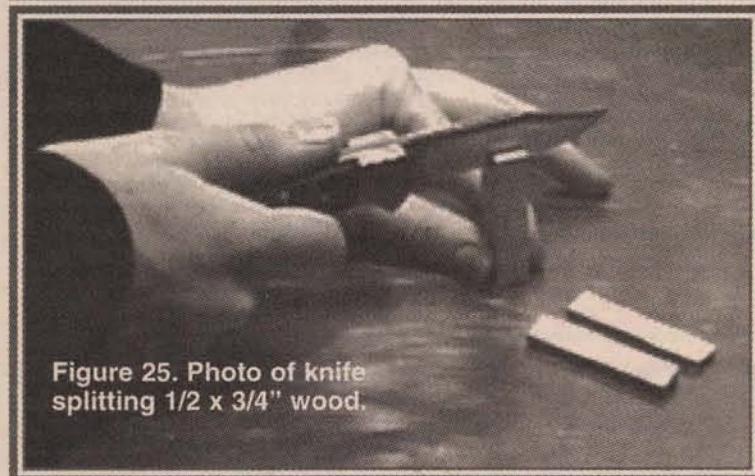


Figure 25. Photo of knife splitting 1/2 x 3/4" wood.

## Development

Develop and view the hologram as described before.

## Checking the Finished Hologram

When you look at the virtual image of this hologram, it will appear as any other hologram shot with a diverging beam. When you look at the real image, by flipping it over, the difference is very noticeable.

Reflection holograms shot with a diverging beam have a real image that is a magnified projection of the model, in contrast to a reflection hologram shot with a collimated beam that has a real image projected at the same size as the

virtual image.

The real image of a hologram is used to make a number of different types of copy holograms. To make undistorted copies requires an undistorted real image. This is why it is necessary to collimate the beam. We can use the hologram we just made to make an image plane hologram.

## Image Plane Copy Hologram

To make an image plane hologram, we project the real image from the master onto an unexposed plate. The advantage this technique has over the "direct reflection copy" is that you can move the plane of the holographic image, meaning that you can move the holographic image in front of, bisecting, or behind the holographic plate. If you ever viewed a hologram where the image is projected in front of the plate, rather than behind it, this is one way you can accomplish this.

Figure 23 shows the basic set-up. H2 (the copy) is placed in front of H1 (the master). The real image from the master is projected forward toward H2.

## Set-Up

### Materials Needed

- 1 Radius mirror with magnetic mounting
- 1 45 degree holographic plate fixture
- 1 H1 hologram (master)
- 1 Holographic plate (H2)
- 1 White alignment card
- 1 Black shutter card
- 1 Large positive lens

The procedure for making an image plane copy is as follows. Use the radius mirror to spread the laser beam diagonally across the table. Place the positive lens in front of the spreading beam to collimate the beam. Check the beam to insure it is collimated. Position the 45-degree fixture so that it intercepts the collimated beam directly.

Start by placing a white alignment card in the 45-degree fixture holder. Check the spread beam to make sure the beam is evenly illuminating the

white card. Remove the white card and replace it with a dummy glass plate. The dummy glass is necessary to accurately gauge where the fresh plate (H2) will be positioned. At this point, you can add spacers behind the glass to vary where the real image will bisect the copy plate. If you do not use spacers, chances are that the entire image will be projected in behind the plate of the image plane copy (just like the original). In many cases, holographers make the image bisect the plate, allowing half of the image to project in front of the plate and the balance of the image behind the plate. See close-up in Figure 24.

Spacers can be made from the same wood used to make the "U" channel on the 45-degree fixture ( $1/2" \times 3/4"$ ). Cut a  $1\frac{1}{2}$ " length of this wood, then, using a sharp knife, split the wood into four equal pieces along the  $3/4"$  thickness, as in Figure 25. If you use the spacers, place one spacer on each side and on the bottom of the glass plate in the 45-degree fixture. Next, place the master hologram on top of the spacers, so that the real image is being displayed.

To produce the brightest real image from the master H1, you will have to tilt the plate slightly. Rather than tilt the plate itself, tilt the entire 45-degree fixture. At the angle it produces the brightest real image, place spacers under the fixture to hold the fixture at that angle.

## Making the Exposure

Remove the master H1 from the 45-degree fixture; note the orientation when you take it out and place it down. You must reload this plate exactly as it was or you will not make a copy hologram. Next, remove the spacers and the dummy glass plate.

Shutter the laser, turn off the room lights, and turn on the safe lights. Load a fresh holographic plate (H2) into the fixture. Next, put the spaces on top of the H2 plate. Finally, replace the master hologram into the fixture making sure it is orientated properly.

You may want to place a little clay on the top corners of H1 to secure it in position. Make your exposure using the shutter card. Use the same exposure time as you had used to make the master hologram. Develop for a reflection hologram as before.

## Results

When you look at the copy hologram at first, it may appear like the original. Look closely and you will notice that the holographic image is being projected in front of (or bisects) the holographic plate. NV

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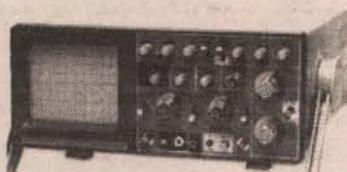
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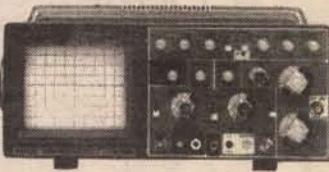
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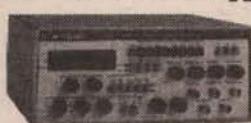
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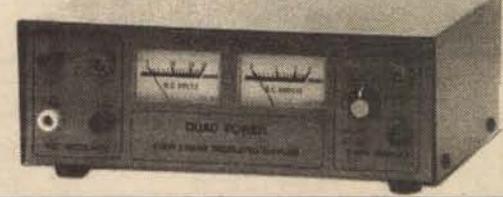
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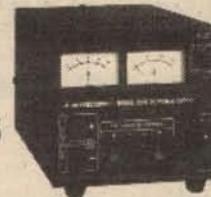


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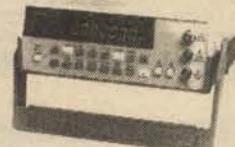
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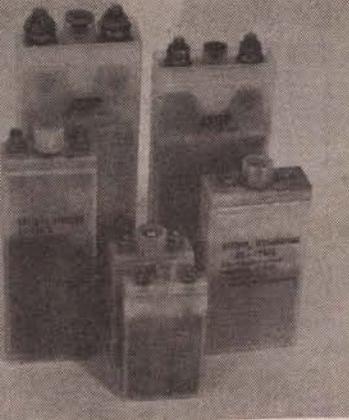
**VISA**

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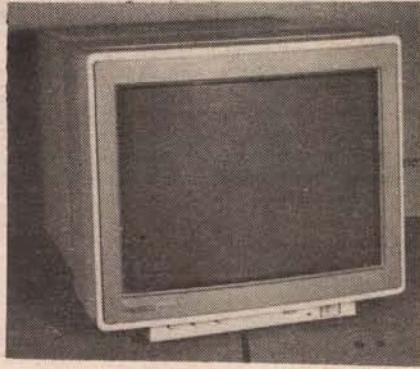
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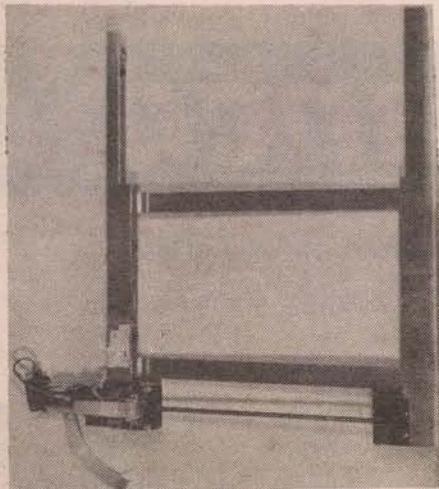


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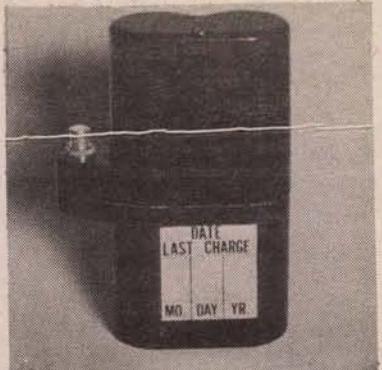


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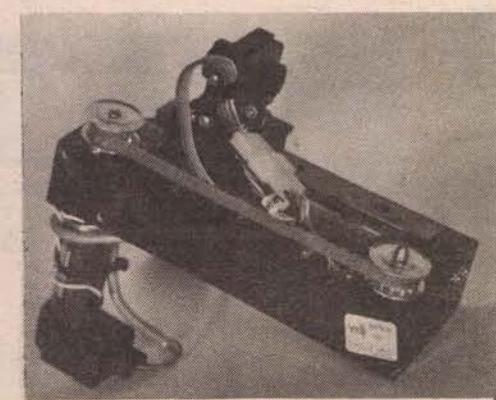


**Linear Motion Mechanism.** This consists of a pair of timing belts that move a cross slide. It is driven by a Maxon DC gearhead motor with a Hewlett Packard encoder. The assembly includes opto limit switches. 15" motion 0.005 accuracy. Excellent for mat cutters, sewing machines, light machining.....\$99.00 Postpaid



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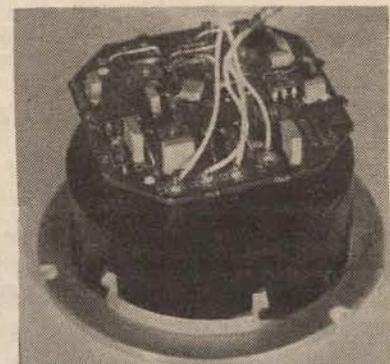
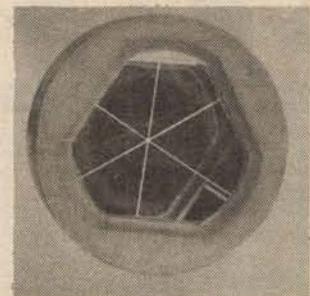
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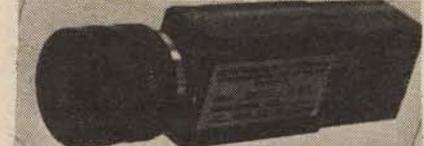
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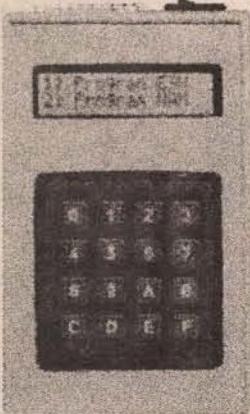


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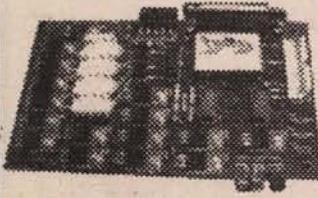
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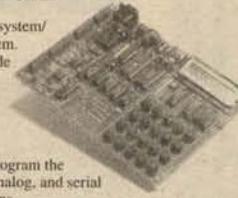
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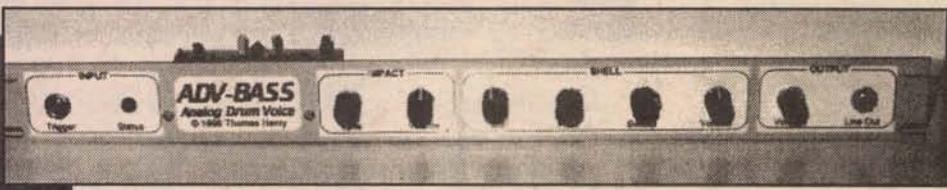
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# Build the ADV-BASS

## A New Analog Drum Voice for Percussive Musical Effects

by Thomas Henry and Jack Orman

**Here's an inexpensive, yet professional, analog drum voice you can easily build.**



Called the ADV-BASS, it has been carefully designed to do an especially good job of emulating bass drums. But wait, there's more! The ADV-BASS can produce many different musical sounds including tunable tom-toms, woodblocks, claves, and any number of "outer space" effects. Best of all, it is easily controlled by hand or computer.

The ADV-BASS makes its appearance at a time when there's a renewed interest in analog musical synthesis. If you haven't noticed, in the past year or so many musicians are returning to such instruments in the belief that they sound more natural than their digital counterparts. See if you don't agree that the fidelity and versatility of the ADV-BASS far surpasses most digitally sampled percussion units.

If you're building up a complete drum system for use on stage or in the recording studio, then this makes a great companion to the ADV-SNARE which was described in the July '96 issue of *Nuts & Volts*. Or, as a stand-alone unit, it is ideally suited for any number of special applications. For example, couple it with a counter circuit and you've got a great start on a very natural sounding metronome, perfect for dance or piano rehearsals.

Before looking at the circuit in detail, let's take a moment to understand why a bass drum sounds the way it does.

### BASS DRUM BASICS

When a bass drum is struck by a beater (either a foot-operated or a handheld one) two sounds are gener-

ated. First, there is the effect of the beater itself striking the drum head. This is called the impact. The impact could range from a sharp crack to a dull thud, depending on the material covering the business end of the stick. Typically, though, the tips of beaters are covered with a heavy fabric and so produce a rather muffled sound.

Immediately after the impact, the drum shell itself begins to resonate. Not surprisingly, this sonic component is called the shell resonance. The shell resonance is

characterized as a damped sinusoid. When the drum head is struck, vibrations are excited within the hollow cavity and will gradually die away. Both the pitch and decay time depend on the size of the drum, as well as the tightness of the heads.

However, there is one other subtle attribute that isn't immediately obvious to the untrained ear. When the head is struck by a beater, it is deformed somewhat. This alters the quantity of air within the drum cavity, and hence the resonant frequency. The pitch moves higher momentarily.

As the head settles down, air rushes back in to fill the drum again, and the pitch drops to its original value. This frequency modulation happens so fast that the human ear really doesn't perceive it as a pitch bend, but rather as a blip adding to the overall complexity of the sound. Any electronic circuit which claims to accurately recreate a bass drum had better incorporate this rapid detuning. Failing to do so leads to a drum sound which is flatter than a pancake!

The ADV-BASS takes all of these sonic components into account, giving realistic results on a very reasonable budget. And unlike digital drums which lock you into a particular sound or style, the ADV-BASS permits continuous control over all of the parameters. So not only will you be able to dial in an excellent bass drum effect, but you will also be able to explore a multitude of other percussive sounds.

### UNDERSTANDING THE CIRCUIT

Despite the excellent sound quality it's capable of, the ADV-BASS circuit is straightforward and designed

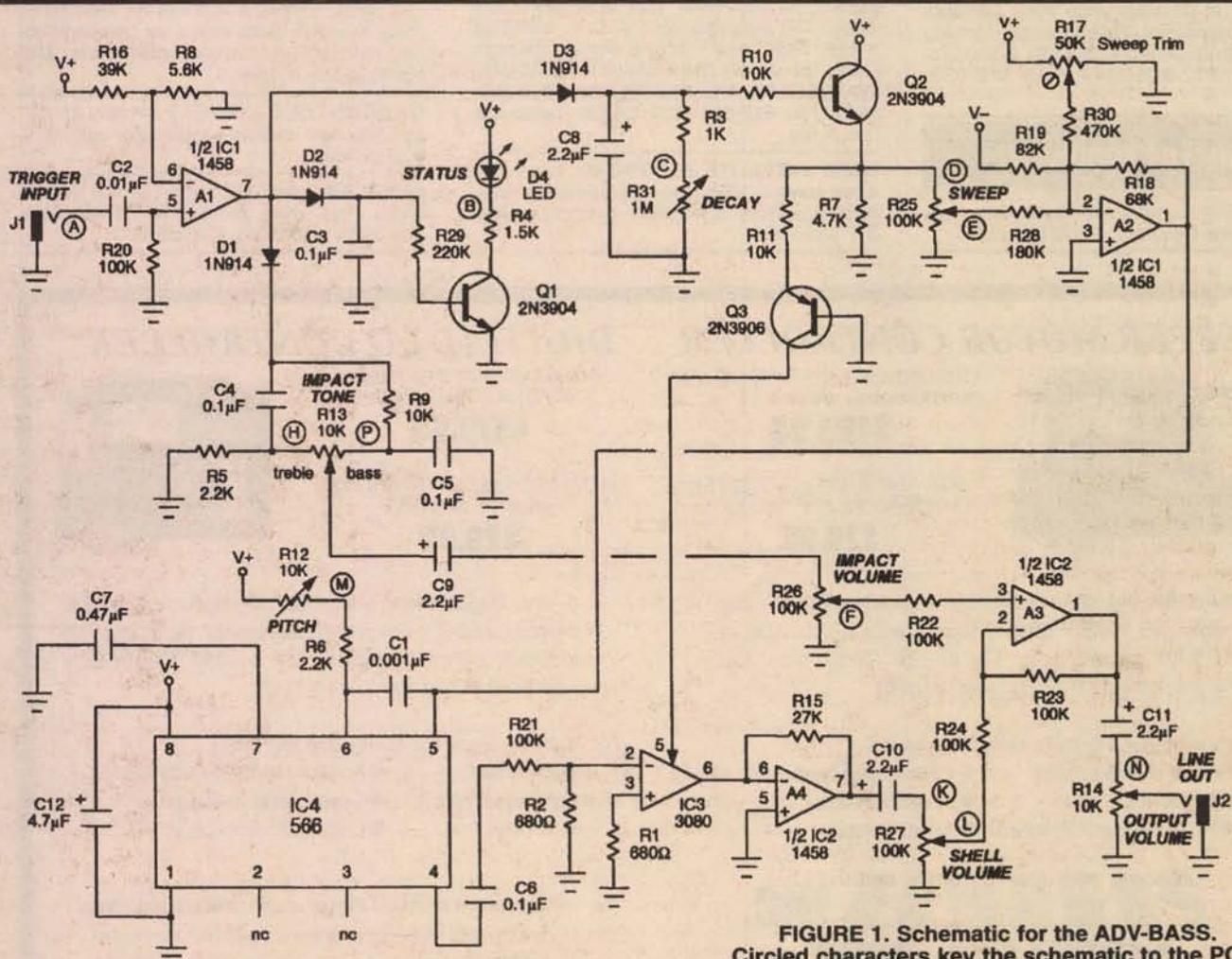


FIGURE 1. Schematic for the ADV-BASS. Circled characters key the schematic to the PCB.

## PARTS LIST

All resistors are 1/8-watt, 10% values

R1, R2	680 ohms
R3	1K
R4	1.5K
R5, R6	2.2K
R7	4.7K
R8	5.6K
R9-R11	10K
R12, R13	10K linear potentiometer
R14	10K audio potentiometer
R15	27K
R16	39K
R17	50K trimmer potentiometer
R18	68K
R19	82K
R20-R24	100K
R25	100K linear potentiometer
R26, R27	100K audio potentiometer
R28	180K
R29	220K
R30	470K
R31	1M linear potentiometer

All capacitors are rated at 16V or better

C1	0.001 mfd mylar
C2	0.01 mfd mylar
C3-C6	0.1 mfd mylar
C7	0.47 mfd mylar
C8-C11	2.2 mfd electrolytic
C12	4.7 mfd electrolytic
C13, C14	10 mfd electrolytic

### Semiconductors

D1-D3	1N914 diode
D4	LED
Q1, Q2	2N3904 NPN transistor
Q3	2N3906 PNP transistor
IC1, IC2	1458 dual op-amp
IC3	3080 transconductance op-amp
IC4	566 function generator

### Other components

J1, J2	1/4" phone jack
--------	-----------------

**Miscellaneous:** IC sockets, LED holder, front panel, knobs, circuit board or perfboard, wire, solder, etc.

## ORDERING INFORMATION

The following items are available from:

### Midwest Analog Products

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US and Canadian orders add \$2.00 S/H for the printed circuit board alone or \$4.00 S/H for the printed circuit board and kit of parts. Write for shipping information to other countries.

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yielding an output which goes from about +12V down to +8V.

This particular range makes the 566 happy. Moreover, notice that the sense of the control is correct now. By the way, trimmer R17 is used to tweak the sweep range, maximizing the modulation effect. We'll see how to adjust R17 later on.

The modified envelope signal is then fed to pin 5 of the 566 and will cause the VCO to sweep in sync with the envelope. C1 is used to stabilize the control voltage input, while C12 decouples IC4 from the rest of the circuitry.

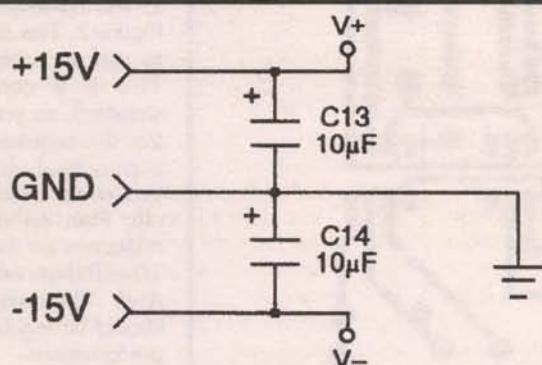
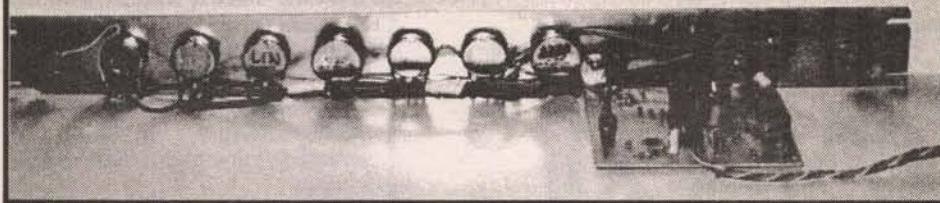
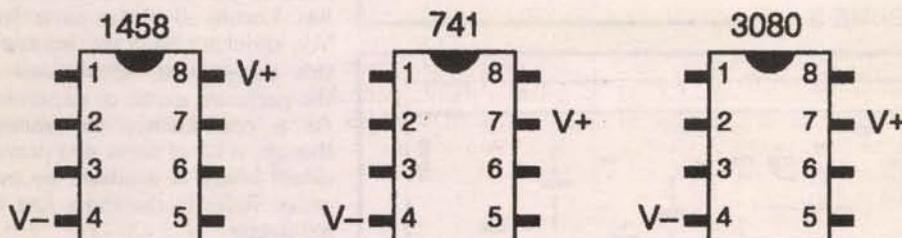


FIGURE 2. Power supply details for the ADV-BASS.



Power Supply Connections to the Op-Amps

around common electronic components. Refer to the schematic in Figure 1.

The ADV-BASS can be fired by just about any source of triggers you can imagine. In the recording studio, some examples might include the outputs of dedicated rhythm generators or computer ports. Another possibility is using a MIDI-to-trigger interface to convert MIDI signals to +5V triggers. (MIDI is the industry standard interface for interconnecting electronic synthesizers, personal computers, and recording equipment.)

For live use, it is also quite simple to trigger the unit by means of a preamplified transducer or microphone. In this case, striking the transducer or something near it generates an electrical impulse which then fires the ADV-BASS. Since there are so many ways to use the device, it is important that the input circuitry be sensitive, yet rugged. Op-amp A1 and its associated circuitry implement this interface.

First, a source of triggers is pumped into jack J1. C2 and R20 then differentiate the signal, creating a spike. This is squared up into a pulse about one millisecond wide by op-amp A1, which is actually configured as a comparator. R8 and R16 set a basic threshold of about +1.9V. Any input voltage which exceeds this value is guaranteed to push the comparator into action. Notice also that A1 is capable of handling a wide range of inputs, so the remaining circuitry is protected from any trigger which is too "hot." Thus, just about any input with a peak value of more than a couple of volts can be used to trigger the ADV-BASS safely.

Negative swings of the comparator will be rejected by diodes D1 through D3. D2 energizes the Status LED circuitry giving you visible confirmation that the circuit is responding. Since the conditioned trigger is a mere one millisecond wide, it needs to be stretched sufficiently so that it will light LED D4 long enough to be visible. When D2 conducts, a charge is dumped onto C3 where it is held for a brief period. Transistor Q1 turns on and allows current to flow (suitably limited by R4). Eventually, the charge will drain off of C3 and the LED goes dark again.

The shell resonance is synthesized by a VCO (voltage controlled oscillator) which feeds a VCA (voltage controlled amplifier), both of which are under control of

an envelope generator. D3 routes the conditioned input pulse around to the envelope generator composed of C8, R3, and R31.

Now a real drum has a virtually instantaneous attack. To imitate this, the conditioned trigger passed by D3 dumps a charge onto C8 almost at once (limited only by the internal resistance of D3). This voltage is buffered by R10 and transistor Q2. The envelope at the emitter of Q2 rises to about +10V or so. But then the decay sets in. The charge on C8 gradually dissipates through R3 and R31, while the buffered envelope on Q2's emitter follows suit. Notice that R31 allows you to adjust the decay time from the front panel. We'll see how the envelope signal is used in just a moment.

IC4 — the 566 — is a VCO chip. Notice that a trianglewave is produced at pin 4. (A triangle is a close enough approximation to the sinewave for this application.) R6, R12, and C7 set the basic operating frequency of the VCO. R12 is a front panel control that allows you to vary the fundamental pitch of the drum over several octaves.

Pin 5 is the control voltage input. It responds to a positive voltage, but note that the sense of the sweep is inverted. That is, a higher input voltage leads to a lower VCO frequency. This is backwards from what we want, so notice how op-amp A2 is pressed into service to correct things.

The envelope signal is tapped off of the emitter of Q2 and then applied to potentiometer R25. This lets you tame the sweep as required. The attenuated signal is then picked off of the wiper of R25 and applied to A2 and its associated components. The 0 to +10V swing of the envelope generator is inverted and level shifted,

As mentioned earlier, the triangle-wave is present at pin 4. Since this signal has a substantial DC offset imposed on it, C6 capacitively couples it to the remaining audio circuitry.

IC3 is the 3080 transconductance operational amplifier and is configured here as a VCA. To avoid distortion, the inputs of this component should never see a signal of more than 20 millivolts peak-peak. So voltage divider R2 and R21 chop things down appropriately.

Pin 5 of the 3080 is the gain control. This pin expects a current, so R11 and Q3 convert the envelope voltage to a current within the proper range. The output of the 3080 is also a current, but R15 and A4 convert it back to a voltage with a maximum level of 10V peak-peak. (This is a common standard used in many analog synthesizers.)

Thus, with a handful of common components, we've come up with a circuit which modulates not only the frequency of the trianglewave, but its amplitude, as well.

Let's concentrate on the mixer now. The shell resonance is tapped off of pin 7 of op-amp A4, and coupled by C10 into the mixer designed around A3. Volume control R27 lets you set the level of the shell resonance.

Also feeding the mixer is the impact tone generator. Look back to D1 which comes straight from the input trigger conditioner. This pulse, a nice rectangular wave rich in harmonics, is capacitively coupled to two simple filters. R5 and C4 form a simple high-pass filter, while R9 and C5 comprise a low-pass circuit. Potentiometer R13 determines the blend of these two.

At one extreme, the impact sound will be very sharp and brittle, while turning the knob the opposite way gives a duller, smoother thud. This is an exceedingly simple way to create and modify the impact tone, but really does work remarkably well.

The impact is then attenuated as desired by R26 and fed into the mixer. Notice how the non-inverting input of A3 is used here. This is to keep the sound additive in nature, rather than subtracting it from the total mix. Finally, R14 is used to set the overall volume of the ADV-BASS sound.

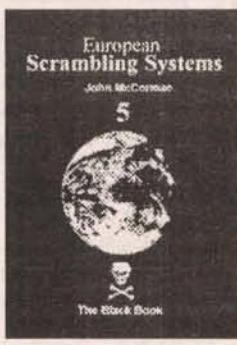
The power supply connections to the op-amps are illustrated in Figure 2. The circuit was designed to run on a bipolar 15V supply. This is a common synthesizer standard, so you might be able to tap the required voltages from a commercial unit. Alternatively, you could build a dedicated supply. Plan on drawing about 20 milliamps on the positive side and 10 milliamps on the negative side. And obviously, the voltages should be regulated for best audio performance.

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## BUILDING THE ADV-BASS

Since this is a fairly simple and non-critical circuit, building the ADV-BASS can be quite a bit of fun. Locate all of the parts first. You shouldn't have any trouble in this department, since none of the parts are exotic or expensive. As a convenience to readers, though, a kit of parts and printed circuit board is available by mail order. Refer to the Parts List for full details.

Next, decide what construction method you will use. A hand-wired perfboard approach is perfectly suitable, as long as you are relatively neat. Since there are several hot signals running about, keep your wiring tidy to avoid any undesired interaction. This will also make troubleshooting — if required — much easier, as well.

The most reliable attack would be to use a printed circuit board. Figure 3 shows the full scale artwork for the foil side of the circuit board, while the parts placement guide is shown in Figure 4. If you have the necessary equipment, you can etch and drill your own board. But many readers will probably want to take advantage of the commercially produced one. Again, the Parts List will help you in this regard.

If using the printed circuit board, take note of the orienta-

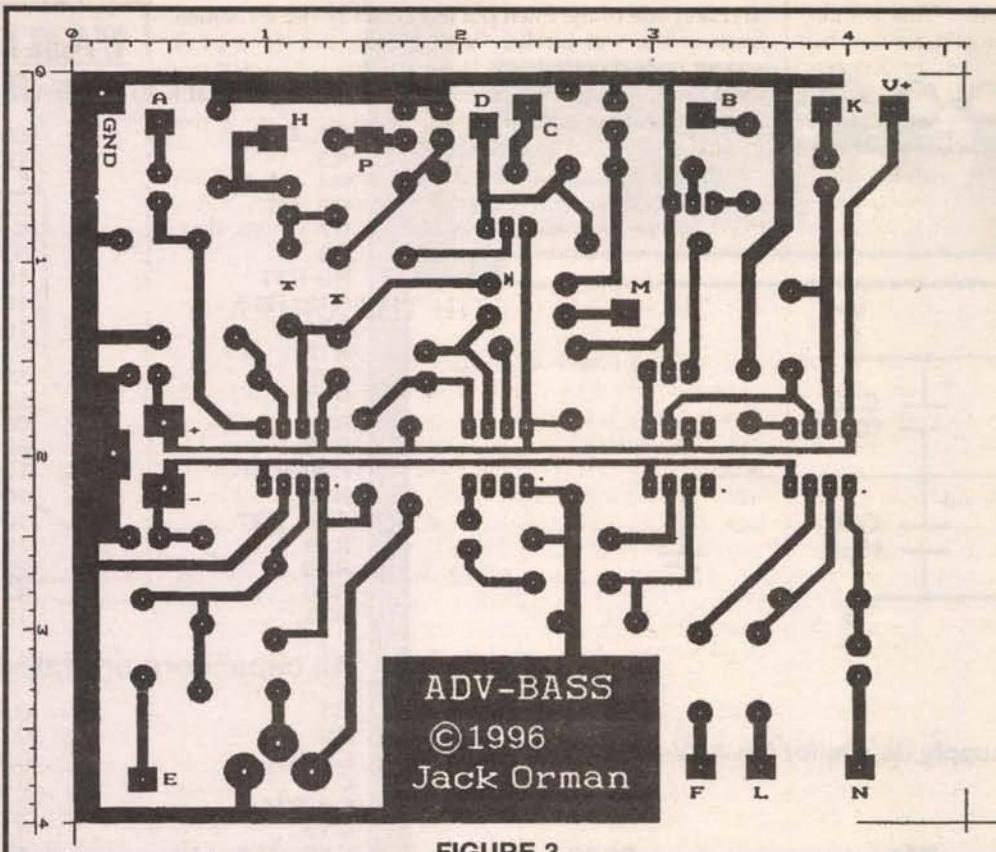


FIGURE 3

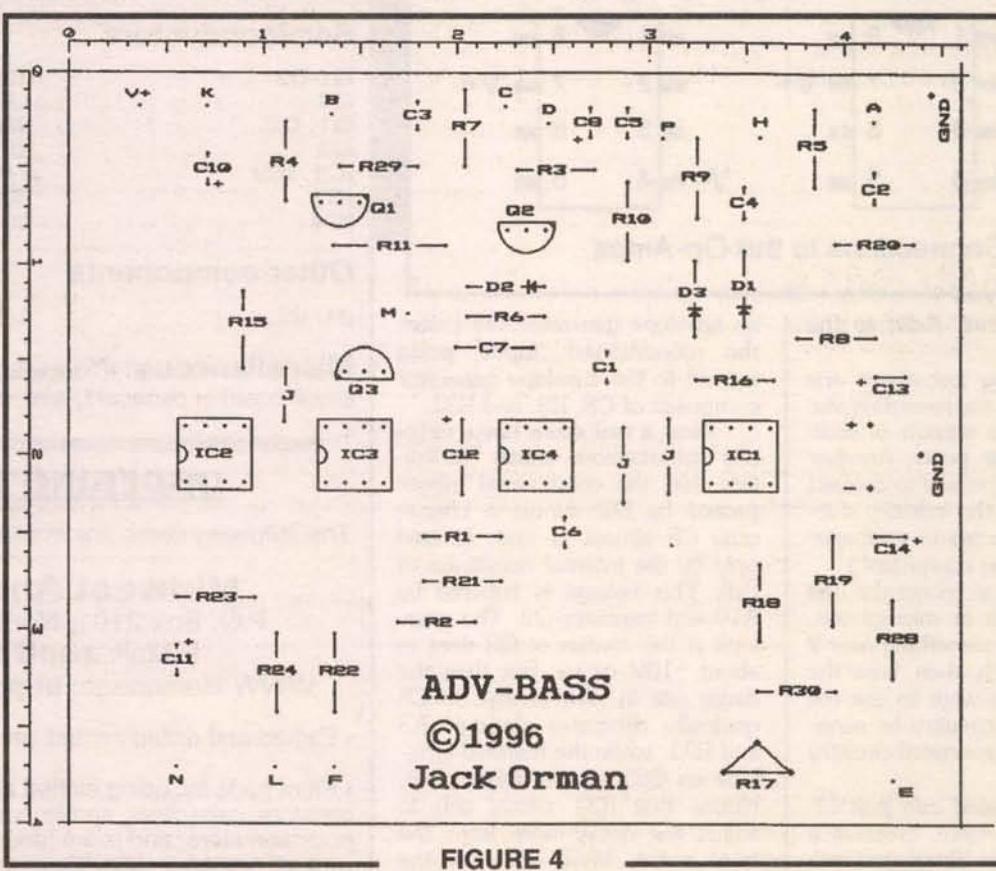


FIGURE 4

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tion of the various polarized components. This is indicated on the parts placement guide in Figure 4. The positive leads of the electrolytic capacitors are denoted by a plus sign (+), while diode placement is indicated by the schematic symbol (the cross bar means cathode). IC orientation is shown by a notch on the end nearest pin 1 of each. Figure 5 shows the pinout assumed for all of the transistors. Since some manufacturers alter this layout, you might want to check your transistors first before soldering them in place.

Three jumpers are required, and these are denoted by the letter "J." You can use snippets of resistor leads for these, if desired.

By the way, C9 does not mount on the circuit board. Instead, it is wired directly behind the front panel. Using some spaghetti tubing to insulate its leads, solder this cap between the wiper of R13 and the hot side of potentiometer R26.

Most musicians prefer to have their equipment built within standard rack mounts. Figure 6 shows a suitable layout based upon a single height panel (1 3/4" by 19"). If you decide to go with this method, then the drilling guide in Figure 7 will also prove handy. Incidentally, 1/8" thick aluminum stock is plenty sturdy for a rack panel and is easily worked with. You can buy a piece at just about any local sheet metal firm.

Attaching the loaded circuit board to the front panel is fairly straightforward. Referring to the schematic in Figure 1 again, observe that circled letters key the various front panel controls to the printed circuit board. For example, the letter "L" indicates that the wiper of the Shell Volume control, R27, should connect to the pad labeled "L" on the printed circuit board.

To avoid ground loops which can lead to hum problems, daisy chain the various ground connections behind the front panel controls, and then have a single path from the chain back to the circuit board. Notice that there is a separate pad for this ground (labeled "GND") in the upper left-hand corner. Similarly, the anode of D4

and one side of the Pitch pot (R12) can be daisy-chained back to the pad labeled "V+." Finally, the three large square pads grouped next to each other on the left are used to connect to the power supply. One is labeled with a plus, the next with a minus, while the third is the ground connection to the supply.

If you've double-checked your work and everything looks okay, then apply the power. Assuming that things don't self-destruct from solder blobs or miswirings, then you're ready to let the rhythm rip!

## MUSIC MAKING WITH THE ADV-BASS

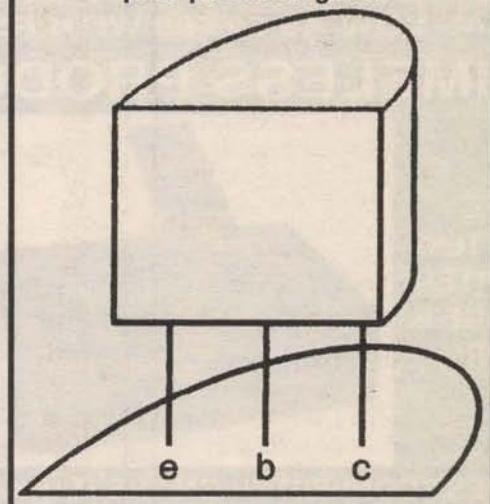
Apply a source of triggers to jack J1. For testing purposes, you could use a pushbutton switch which toggles between ground and V+, or you might find that a function generator set to pump out a squarewave at around 0.1 Hz will do the trick. Turn down all of the front panel controls and then connect an amplifier to jack J2. Confirm that the Status LED blinks in sync with the triggers.

Let's check out the shell resonance and also set trimmer R17. Turn the Decay and Sweep front panel pots to maximum, and then ease up the Shell Volume and Output Volume controls. You should hear a trianglewave which descends in pitch each time the unit is fired.

Now adjust trimmer R17 until the sweep is smooth and continuous, with no dead spots. Although this description seems somewhat vague, you will have no trouble knowing when you've found the right setting. In a nutshell, you simply want to get the maximum pitch detuning over the course of the entire envelope. Once you set this trimmer to a value you like, you can leave it. You're now ready to start making music.

Like any musical instrument, the key to using the ADV-BASS profitably is practice. Don't be surprised if it takes you a while to get used to the controls and how they work. And by all means, don't give up on a partic-

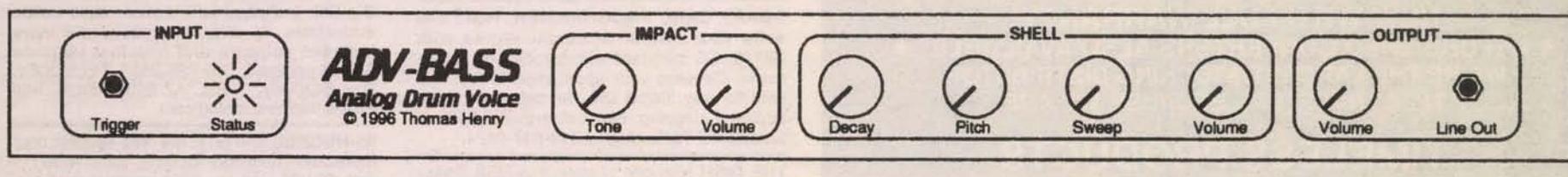
**FIGURE 5.**  
Transistor orientation assumed on the parts placement guide.



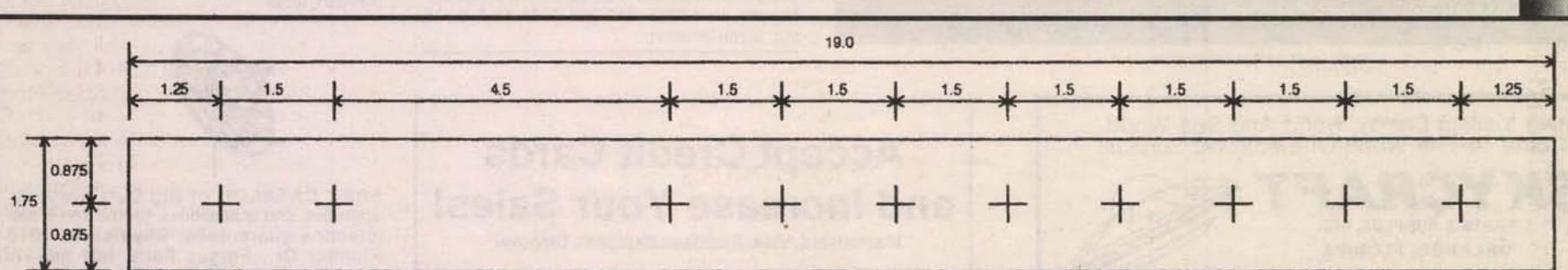
ular sound without spending the time to see if a gentle tweak of one of the parameters firms things up.

For example, it's really easy to overdo the Decay and Sweep controls. But the careful musician will find many different trap kit sounds are possible just by backing up on the pots slightly. Even though we tend to think of drums as a raucous "bash-boom-bang" affair, the subtlety of the sonic components and their mix is often quite surprising.

So what are you waiting for? Build the ADV-BASS and start rehearsing. You're ready to enter an exciting new world of analog drum synthesis! NV



**FIGURE 6.** ADV-BASS front panel.



**FIGURE 7.** Front panel drilling guide (all measurements in inches).

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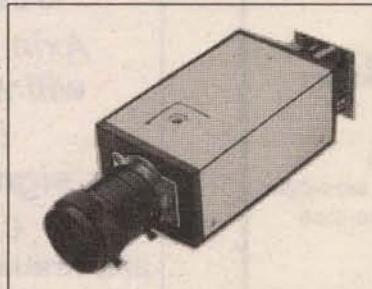
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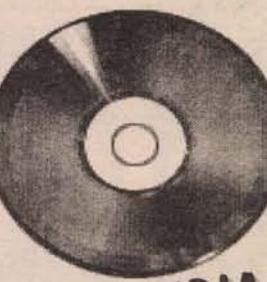
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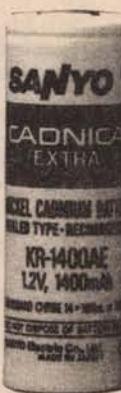
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Integration is the mathematical process of finding the area under a curve. Uses include: 1) acting as a low-pass filter; 2) finding the area under the curve; and 3) finding the time-average of a varying waveform (which is related to the second use). If you want to find the area under a time varying voltage, then you might apply the mathematics of integral calculus to arrive at a number. Alternatively, you might use an analogue integrator circuit. The same circuit can also be used to find the time average of a varying voltage.

## Time Average

In Figure 1, a time-varying voltage signal represents a pressure transducer output. In this particular case, the signal is the output of a human arterial blood pressure transducer used in medical electronics (any other example would also suffice). Notice that the pressure/voltage varies with time from a low non-zero value ( $P_D$  or "diastolic") to a high peak value ( $P_S$  or "systolic") between times  $T_1$  and  $T_2$  (which represents one cardiac cycle). If we want to know the mean arterial pressure (MAP), then we would want to find the time-average, then we would find the area under the curve and divide by the duration, as shown by:

$$\bar{P} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} P dt + c \quad 1$$

Before discussing the circuit, let's first mention the math notation. The  $\int$  symbol indicates that the integration process will be applied on the pressure signal,  $P$ , over the time interval  $t_1$  to  $t_2$ . The "dt" indicates that the integration takes place with respect to time. The

mean arterial pressure over the  $t_2-t_1$  interval, also denoted by  $P_{\bar{P}}$ , is the integral of the voltage signal representing the pressure. The  $c$  is to take care of any offset or constant present. From this illustration, we can see that the integrator serves to find the time-average "mean" value of an analog voltage waveform — it doesn't have to be a blood pressure signal.

As an aside, I worked for a number of years repairing medical electronic equipment. Many clinical monitors use internal analog or microprocessor-based integrator circuits to find the mean arterial pressure (which medical types often called simply "MAP"). Because few nurses know calculus, they are taught a simplification of Equation 1 above:

$$\bar{P} = MAP = P_D + \frac{P_S - P_D}{3} \quad 2$$

Equation 2 is basically an approximation of Equation 1, which is the real equation. The approximation works well, except for many sick people. Unfortunately, many sick people don't exhibit the waveform of Figure 1, but rather a damped version in which the notch just prior to  $t_2$  is missing, and the pressure simply falls off to the diastolic value. The problem is that this action cuts off about 20 percent of the waveform, which, in turn, makes the calculated MAP too high. When nurses compare the calculated approximation with the instrumented MAP (which is the actual value), they almost always trust their training and demand that the instrument be "repaired."

I've told many of them to check the pressure monitoring system with the Calibrate button (a simulated constant pressure), or to disconnect the transducer from the patient and pump a constant pressure (e.g., 100 mmHg) onto the system. If the instrument is working right, a constant pressure for more than about five seconds (the measurement time constant) will yield very nearly identical readings for  $P_D$ ,  $P_S$ , and MAP. In one case, at 3 am, an intern had to tell her I was right (and he turned out to have an B.Sc in chemistry, which means lots of calculus).

## Passive R<sub>C</sub> Integrator Circuits

Perhaps the simplest form of integrator circuits are made from simple resistor (R) and capacitor (C) elements, as shown in Figure 2. You may recognize this circuit as a passive low-pass filter. The RC low-pass filter (integrator) has a -6 dB/octave falling characteristic frequency response.

# Open Channel

by Joseph J. Carr  
K4IPV

The operation of the integrator is dependent upon the time constant of the RC network (i.e.,  $R \times C$ ). In most cases, we want the integrator time constant to be long (i.e.,  $>10x$ ) compared with the period of the signal being integrated. We can cascade several integrators in order to enhance the effect, and also increase the slope of the frequency response fall off, although only at the expense of severe signal amplitude loss.

## Active Op-Amp Integrator Circuits

The operational amplifier makes it a lot easier to build active integrator circuits. Figure 3 shows the standard operational amplifier version of the Miller integrator circuit. An IC operational amplifier is the active element; a resistor is in series with the inverting input and a capacitor is in the feedback loop. The output voltage of the integrator circuit is dependent upon the input signal amplitude and the RC time constant. The transfer equation for the Miller integrator is:

$$V_o = \frac{-1}{RC} \int_0^T V_{in} dt + K \quad 3$$

where:

$V_o$  and  $V_{in}$  are in the same units (volts, millivolts, etc.)

R is in ohms ( $\Omega$ )

C is in farads (F)

t is in seconds (s)

K is a constant in volts (same units as  $V_o$  and  $V_{in}$ )

The expression of Equation 3 is a way of saying that the output voltage is equal to the time-average of the input signal, plus some constant K which is the voltage that may have been stored in the capacitor from some previous operation (often zero). Alternatively, K may represent an offset error voltage in either the input signal or the operational amplifier itself — and therein is found a problem with textbook integrator circuits.

## Practical Miller Integrator Circuits

The circuit shown in Figure 3 is classic, and appears in textbooks (including mine) and magazine articles. Unfortunately, it also doesn't work very well (or at all in some cases) because

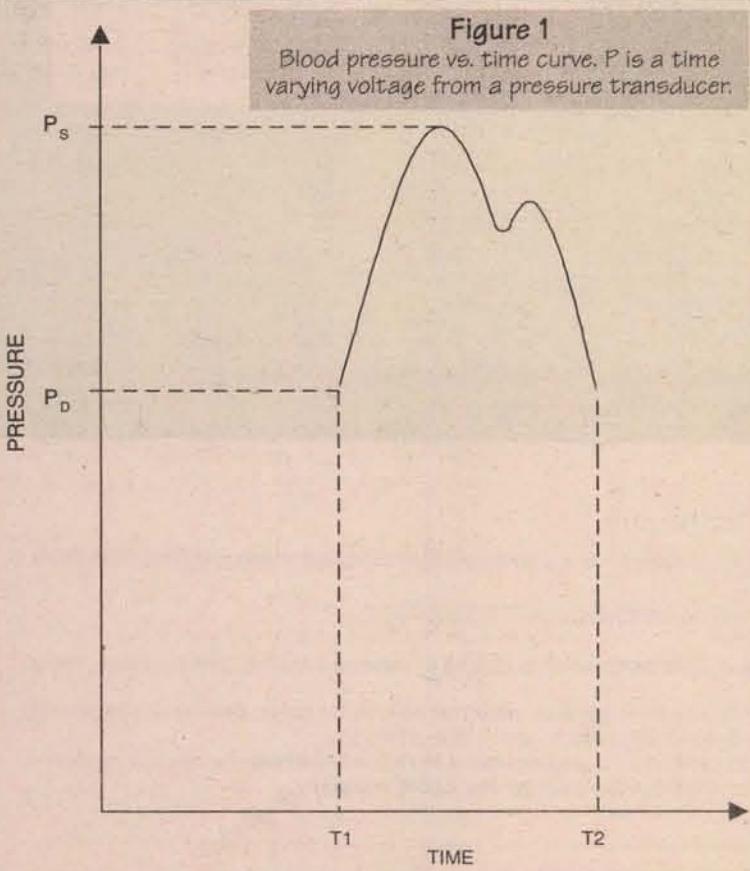


Figure 1

Blood pressure vs. time curve.  $P$  is a time varying voltage from a pressure transducer.

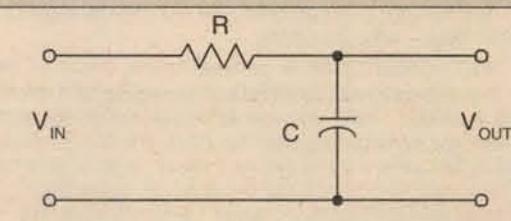
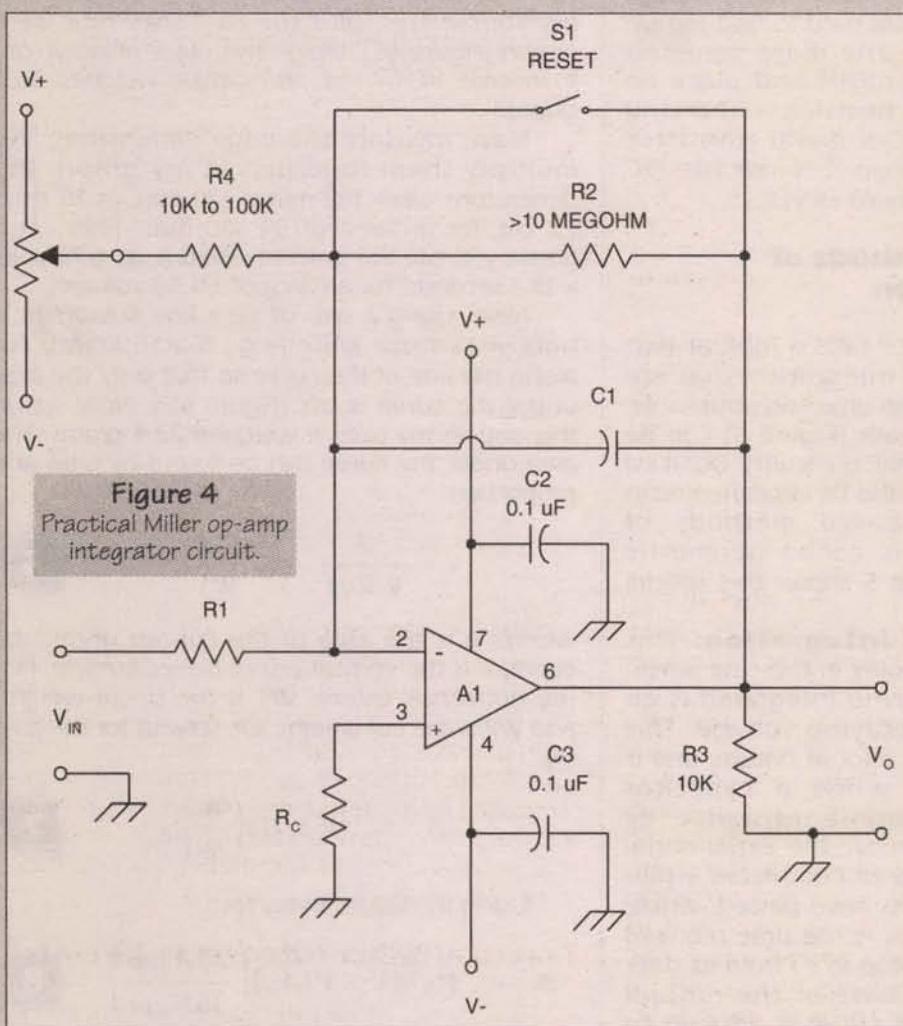
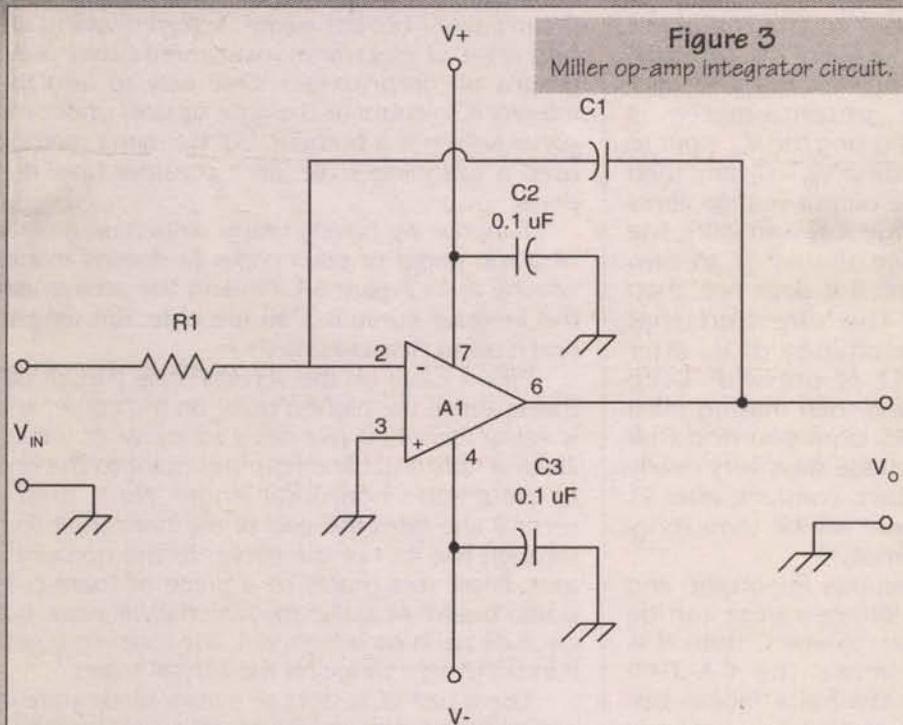


Figure 2  
Passive resistor-capacitor (RC) integrator circuit.

# Open Channel



of the offset voltage problem (a demon!). These circuits are too simplistic because they depend upon ideal input signals that are symmetrical about zero volts, and the properties of "ideal" operational amplifiers. Unfortunately, the real kind-you-can-go-buy op-amps fall far short of the ideal device that was in the mind of the textbook writer. In real circuits, we find that integrators saturate very shortly after turn-on.

The problem with the op-amp integrators was driven home to me when I worked in that hospital lab, and had to build an electronic integrator for one of the customers of our electronics laboratory. When I used a 741 operational amplifier, the output voltage

If we want to keep the output voltage from saturating, then we must either keep the RC time constant under control or prevent the input signal from rising too high (not good!). If the maximum output voltage allowable is 10 volts, then the maximum input signal is 10 volts/10,000 or 1 millivolt. Obviously, the best solution is to keep the RC time constant within bounds.

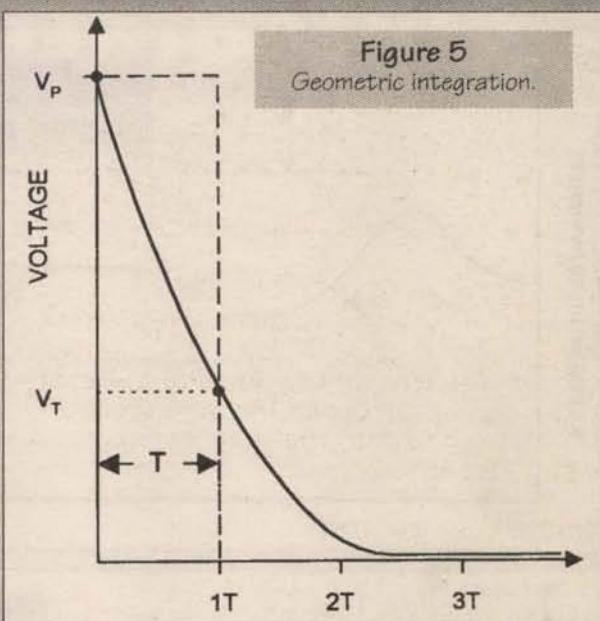
When I built my first analog integrator, and found that 741 devices were not suitable, I turned to the high-cost premium grade op-amp devices. At that time, a premium 725 device cost \$15.00, and it suffered the same problems as the 741. The only difference between the \$15.00

saturated within milliseconds after turn-on. In fact, saturation came so fast that I initially thought the op-amps were bad. The problem was that the input bias currents of the op-amp (which are zero in ideal devices) create a high enough output voltage to fully charge the capacitor in the feedback loop very rapidly.

There is another problem with this kind of circuit, and it magnifies the problem of saturation. This circuit has a very high gain with certain values of R and C. Let's pick an example and see what this gain can mean. The voltage gain ( $A_v$ ) of this circuit is given by the term  $-1/RC$ , so what is the gain with a  $0.01 \mu F$  capacitor (certainly not a "large" capacitor in conventional wisdom) and a 10,000 ohm resistor (note:  $0.01 \mu F$  is  $10^8$  farads):

$$\begin{aligned} A_v &= -1/RC \\ A_v &= -1/(10^4 \text{ ohms})(10^8 \text{ farads}) \\ A_v &= -1/10^4 \\ A_v &= -10^4 = -10,000 \end{aligned}$$

With a gain of -10,000, a +1 volt DC signal applied to the input will try to produce a -10,000 volt output. Unfortunately, the operational amplifier negative output potential is limited to a range of -5 to -20 volts, depending upon the device selected and the applied VDC power supply voltage. For this case, the operational amplifier will slew to saturation very rapidly!



premium op-amp and the \$0.50 741 device is that on the \$15.00 op-amp, the output saturated slowly enough for me to watch it on an oscilloscope or voltmeter — about four seconds — instead of nearly instantaneously. Unfortunately, this was still not acceptable. Applying a waveform to the input of even the premium op-amp integrator allowed me to see the output waveform rise up the screen of the oscilloscope and disappear off the top of the screen!

## How To Solve The Problem

Fortunately, there are some practical design tactics that will allow us to keep the integration capability, while getting rid of the problems. A practical integrator is shown in Figure 4. The heart of this circuit is a BiMOS operational amplifier, type CA-3140, or its equivalent BiFET type (the CA-3130 or CA-3160 will also work; type CA-3240 is a dual CA-3140 with the same pin-outs as an LM-1458). The reason why this device works so well is that it has a low input bias current (having a MOSFET input circuit with a  $1.5 \times 10^{-12}$  ohm input impedance). When I tested close to a dozen different op-amps for the circuit, the CA-3140 — which cost only about \$2.00 — out-performed devices costing 10 times as much.

Capacitor C1 and resistor R1 in Figure 4 form the integration elements, and are used in the transfer equation. Resistor R2 is used both to discharge C1 to prevent DC offsets from either the input signal or the op-amp itself from saturating the device; its value should be 10 to 20 megohms. Resistor R3 also limits the gain at low frequencies. The RESET switch is used to set the capacitor voltage back to zero (to prevent a "K" factor offset) before the circuit is used. In some measurement applications, the circuit initializes by closing S1 (or a relay equivalent) momentarily.

Because of R2 in the circuit, we must place a constraint on the transfer equation: the equation is valid only for frequencies greater than or equal to F in Equation 4 below:

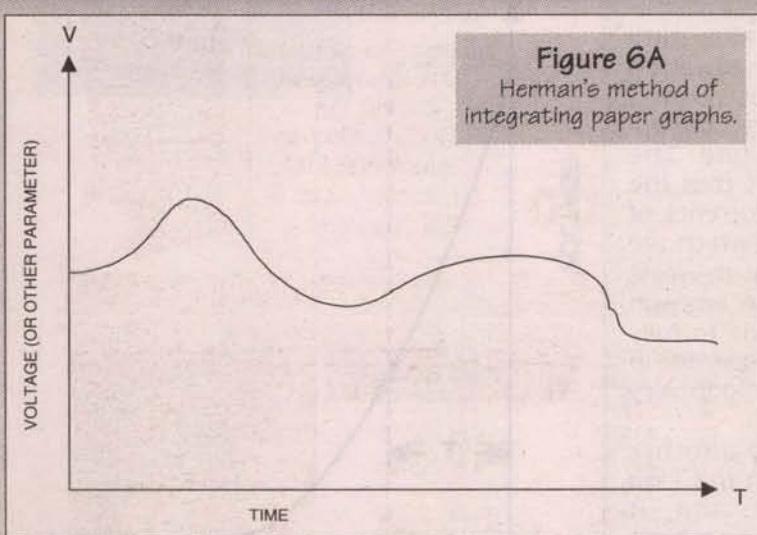
$$F_{Hz} = \frac{10^6}{2\pi R2 C1}$$

where:

F<sub>Hz</sub> is the cut-off frequency in Hertz (Hz)  
R2 is in ohms ( $\Omega$ )  
C is in microfarads ( $\mu F$ )

You can also place a compensation resistor

# Open Channel



countercurrent to the inverting input through resistor R6. To adjust this circuit, set R5 initially to mid-range. The potentiometer is adjusted by shorting the  $V_{in}$  input to ground (or setting  $V_{in} = 0$ ), and then measuring the output voltage. Press S1 to discharge C1, and note the output voltage should go to zero and stay there. If it does not, then turn R5 in the direction that counters the change of  $V_o$  after each time S1 is pressed. Keep pressing S1 and then making small changes in R5 until you find that the output voltage stays very nearly zero, and remains constant, after S1 is pressed (there will be some long-term drift normally).

If drift becomes important, and the output voltage range can be limited to less  $\pm 5$  volts, then it is possible to make the CA-3140 operate in a low-noise mode. Use the eight-pin metal can package type (which are hard to find today), rather than the more common eight-pin miniDIP, and place an expandable heatsink — the kind made for TO-5 metal transistor packages — on it. Limit the DC power supplies to  $\pm 5$  VDC.

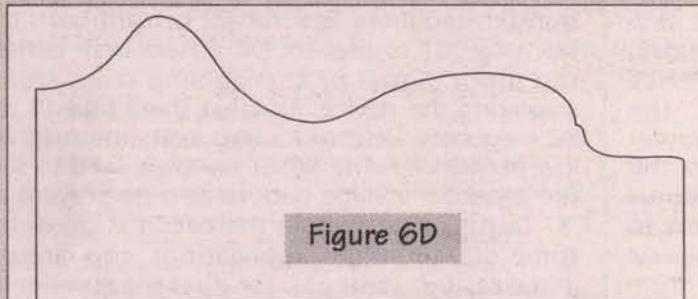
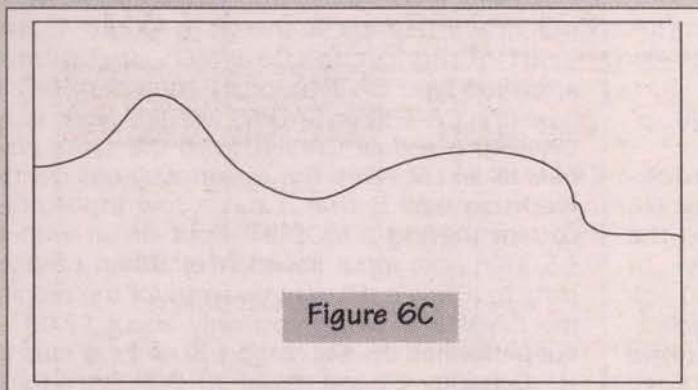
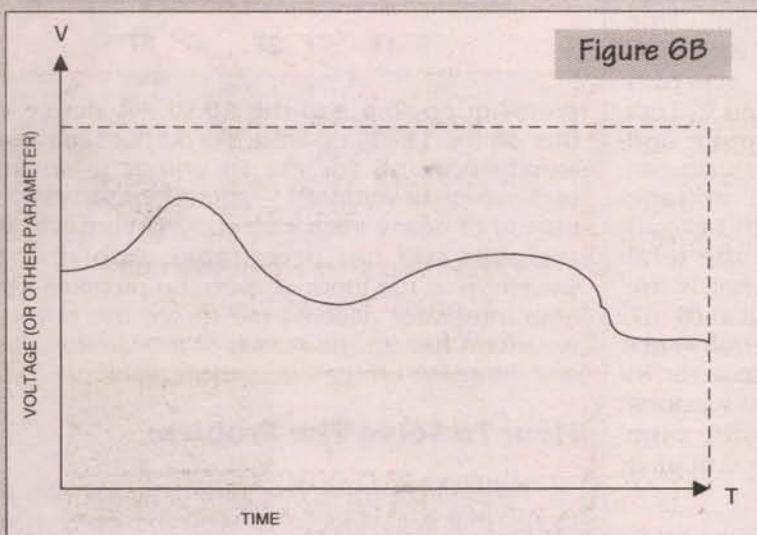
## Other Methods of Integration

Now let's take a look at two methods of integration that are useful under certain other circumstances. One of the methods (Figure 5) can be implemented in analog circuitry, but it's a bit difficult. It can also be implemented in microcomputer-based methods of integration. It is called geometric integration. Figure 5 shows this special case.

**Geometric Integration.** This method is usable only in the case where the waveform being integrated is an exponentially decaying voltage. This waveform is seen a lot in nature, and is also observed when a capacitor discharges through a resistance. By standard convention, the exponential decay is considered completed when five time constants have passed, where one time constant is the time required for the curve to drop to  $e^{-1}$  from its peak value ( $e$  is the base of the natural logarithms). This curve is difficult to integrate, especially if (as so often happens) there is noise present in the regions later than 1T or 2T.

In geometric integration, we create a rectangle with a height equal to the peak voltage of the waveform, and a vertical edge that passes through the 1T point (i.e., point where  $V_T = 0.368 \times V_p$ ). The area of that rectangle is a very good approximation of the area under the exponential decay curve from 0 to 5T. Simply multiply the peak voltage by the time required for 1T to expire, and you will have the area under the curve.

**Herman's Method.** I learned this method from a guy named Herman, or rather Dr. Herman



(call it  $R_c$ ) between the non-inverting input of the operational amplifier and ground. This resistor cancels the effects of input bias current and improves thermal drift performance. It has a value equal to the parallel combination of R1 and R2:

$$R_c = \frac{R1 R2}{R1 + R2}$$

**5**

There may still be a minor drift problem, so potentiometer R5 is sometimes added to the circuit to cancel it. This component adds a small

(I can't recall his last name, sorry Herman). We had a lot of electronic instruments that drew graphs on graph paper. One way to find the integral is to count all the little squares under the curve (which is a bother!). But Herman's method used a weighing scale. Let's consider how it is done.

Suppose we have a graph scribed on a piece of graph paper or plain paper (it doesn't matter which), as in Figure 6A. Finding the area under this irregular curve is a bit tiresome. But we can find it using Herman's method.

Pick a value on the vertical scale (Figure 6B) that is above the highest point on the curve, and is easily identified (we need to know its value). Draw a horizontal line from this point to the end of the graph's horizontal length. Next, drop a vertical line from the end of the horizontal line, through the end of the curve, to the horizontal axis. Paste this graph to a piece of foam-core poster board. Actually, any material will work, but because we have weighed it, the foam core gets it into the right range for most small scales.

Use a pair of scissors or a razor-blade knife to cut out the figure along the vertical and horizontal axes, plus the two lines that were drawn (Figure 6C). Weigh this piece of graph-on-foam-core. In my test, the sample weighed 36.8 grams.

Now, measure the edge dimensions and multiply them together. In my graph, the dimensions were 180 mm x 220 mm, or 18 cm x 22 cm, for an area of 39,600 mm<sup>2</sup> (396 cm<sup>2</sup>). Better yet, use the units involved (e.g., 6.78 volts x 19.4 seconds, for an area of 131.53 volt-sec).

Next, using a pair of very fine scissors or a hobbyist's razor knife (e.g., X-acto knife), cut along the line of the curve so that only the area under the curve is left (Figure 6D). Now weigh this one. In my case, it weighed 22.4 grams. The area under the curve can be found by ratio and proportion:

$$\frac{A}{V \times H} = \frac{W_2}{W_1}$$

**6**

where: A is the area of the cut-out under the curve, V is the vertical extent before cutting, H is the horizontal extent, W<sub>1</sub> is the uncut weight, and W<sub>2</sub> is the cut weight. Or, solving for the area (A).

$$A = (V \times H) \left( \frac{W_2}{W_1} \right)$$

**7**

Using the values in my test:

$$A = (6.78V \times 19.4s) \left( \frac{22.4 \text{ gm}}{36.8 \text{ gm}} \right)$$

**8**

It's a little hokey, but at one time that's one of the few ways we had to integrate curves (unless you had an expensive planograph machine!). It worked ... and a lot of scientific papers were written based on using this method to integrate. NV

## Connections ...

I can be reached at P.O. Box 1099, Falls Church, VA 22041, or via Internet E-Mail at [carrjj@aol.com](mailto:carrjj@aol.com) — I would be pleased to hear from you.

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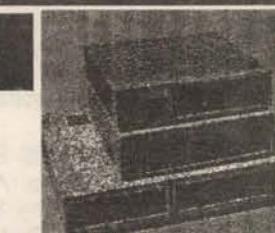
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In this column, I answer questions about all aspects of electronics, including computer hardware and software. This column doesn't replace the Tech Forum that you've grown to love and support. Instead, it will supplement it, so feel free to participate as always with your questions and answers. You can reach me on America Online at **TJBYERS**, on the Internet at **TJBYERS@aol.com** or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 91719.

### The EDO Mystery Unravels

**Q.** I have a 486DX4-100 PCI motherboard with 8 MB of RAM that I bought just six months ago. A few days ago, I bought a 16 MB EDO SIMM and installed it. To my horror, the PC wouldn't boot. I tried taking out the 8 MB module, but still nothing! So I put the old SIMM back in and removed the EDO, and the system booted. I've tried just about everything from changing the CMOS to cleaning the edge contacts. Nothing seems to make the EDO work. I guess I've got to exchange the EDO for a standard SIMM. Sigh.

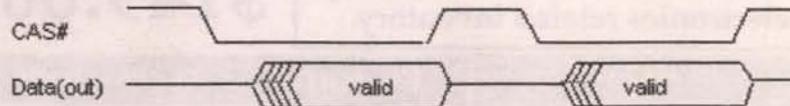
**Charles D. Talmage, Jr.**  
via Prodigy

**Q.** Just wanted to let you know that EDO SIMMs are not compatible with my 486DX4-100 OPTI895 Green motherboard. It's quite a hassle to order, then have to return SIMMs for exchange. Perhaps you could publish a list of known EDO incompatible motherboards as part of your column.

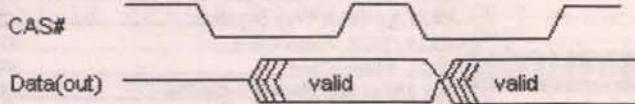
**John W. McMichael**  
via Internet

**A.** Okay guys and gals, the mystery of EDO compatibility is starting to unravel. Best of all, the solutions are coming straight from the horse's mouth — you, the user. Theoretically, standard FP (fast-page) SIMMs and EDO SIMMs should be interchangeable. However, that's not always the case, as a few of us have discovered. First a little theory. When you work with any semiconductor, be it a complex CPU or lowly transistor, it takes time for things to happen. With RAM, the wait is the time it takes to input the logic voltage (high or low; 1 or 0), and let it stabilize before it can be locked into the registers. If the RAM doesn't wait long enough before latching the value, you get errors. That's why 60 ns RAM is faster than 80 ns RAM — it takes 20 ns less time to stabilize. The amount of time the CPU waits before accessing the data is controlled by the CAS clock. Look at the diagram below. On the top, you see the timing sequence of a standard FP SIMM, and on the bottom, you see that of an EDO SIMM.

#### Standard Page-mode DRAM



#### EDO DRAM



In both cases, the loading of the memory takes place when CAS goes low, or on the falling edge, as the engineers describe it. CAS remains low until the CPU decides that the RAM has had enough time to settle down. Here's where the two memories differ. With an FP SIMM, going high tells the FP that it's time to output its stored data. The next falling edge tells the FP to acquire another data byte and wait for the next rising edge. As you can see, there's a rather substantial time lag between when the data is delivered and when the next cycle begins. That's because the CPU itself is a semiconductor, and it takes time to bring the CAS line low again. This is dead time in which the FP SIMM simply sits on its hands waiting for something to happen. The EDO SIMM works faster because it doesn't recognize the rising edge. This allows the CPU to pull the CAS line high while the EDO is stabilizing. What EDO is looking for is the next falling edge — the cue that it's time

to unload its data. The CPU takes advantage of this feature by integrating the CAS low/high transitions into a time frame that exactly equals that of the EDO's access time. So when the CAS line goes low this time, it causes the EDO to deliver the goods — plus it starts a new acquisition cycle. Hence, there is no RAM down time; one cycle follows the next.

The fly in the ointment is the chipset, the traffic controller who coordinates the activities of the CPU, BIOS, and bus so there are no traffic jams. The problem is that some chipsets are better traffic cops than others. Fortunately, there are things you can do to help "Mr. Friendly" along. First, it's not a good idea to mix FP and EDO in the same system. But if you must, place the EDO in the first bank and the FP in the second, then adjust your CMOS set-up for plain-vanilla memory using the PC vendor's recommended number of wait states. If you've upgraded to EDO only and are having trouble, remove the EDO and go back to your FP SIMMs. Now go inside the CMOS set-up and disable all the memory enhancements (the zero wait states, too). Then, re-install the EDO and add the enhancements back one by one until you have a stable system. Unfortunately, there are some really bad cops out there, that, no matter how hard they try, can't direct traffic. I don't want to point fingers, but OPTI chipsets are the most reported offenders, and Intel's are the least. The bad part is that chipsets aren't upgradable like BIOS; they're soldered in place. So when all else fails, you'll have to bite the bullet and exchange your new EDOs for FPs. Remember, now, nothing here is carved in stone. While the basics came from the professionals, the solutions came from you, and more are pouring in everyday. This is one time when your two cents really counts, so spend it.

### Needs Simple RC Receiver

**Q.** I have seen many circuits for simple FM transmitters for wireless microphones and other monitoring devices. Is there an equivalent simple FM receiver that would support remote control of systems like the "Solar Powered Sprinkler" in the Oct. '96 issue? I'm interested in control ranges of a few hundred feet.

**Ed Wilent**  
Poway, CA

**A.** The reason you haven't seen many simple FM receiver circuits is because they aren't all that simple. What I suggest is using an RC transmitter/receiver (the kind you can get at Radio Shack for about \$11.95) for an application as simple as this. What you do is buy their cheapest toy car and cannibalize it for the receiver. Still want to build your own? National Semiconductor used to sell an LM1872 IC that would do this, but it's now obsolete and I can't find a suitable replacement. Hello readers! Help me. I know similar ICs must exist.

### Seeking Used Solar Panels

**Q.** I tried to access [www.asis.com/aee/sepm.html](http://www.asis.com/aee/sepm.html) for information on solar panels and got a message that the site is no longer on line. Any suggestions?

**M. Clegg Esq.**  
via America Online

**A.** Well, the site is still there, but the link seems to be broken. You can access this information at [www.asis.com/aee](http://www.asis.com/aee) (in other words, drop the sepm.html extension). Here's a short list of other sites where you can buy new and used photovoltaic panels.

<http://www.indra.com/jade-mtn/pv.html>  
<http://www.rt66.com/carrizo/>  
<http://www.solarex.com/>

### Nefarious Uses For PC Power Supplies

**Q.** In the Sept. '96 issue of *Nuts & Volts*, you had an article on how to repair PC power supplies. In it, you covered everything except for the orange Power OK signal. I have two old IBM power supplies that I'd like to use in other applications, but they won't run without being connected to the motherboard. I've tried to fool the power supply by connecting the orange lead to one of the +12-volt lines, but that only works for a short time. After the power supply capacitors discharge, the power supply starts for about 1/2 second then quits. What

signal is Power OK looking for and where can I find it?

Ken S.  
via America Online

**A.** Power OK is a logic output signal — not an input — and it has nothing to do with the operation of the power supply itself. This signal is normally high (+5 volts), and indicates that the power supply is working properly. If it goes low, for any reason, its purpose is to halt the CPU's clock and stop the PC. So that's not your problem. It could be that plugging the orange lead into the +12-volt line is causing a problem, but I doubt it from your description. It sounds to me like the power supply isn't properly loaded. With few exceptions, PC power supplies won't run if they don't have a load — in some cases a substantial load. What I suggest is that you hang a six-volt car bulb, like a #1493, on the five-volt line and see if that solves your problem.

### On The Road Again

**Q.** Regarding your article about road warriors in the Oct. '96 issue, "A Road Warrior's Survival Guide," you say Japan runs on 110 volts. From past experience, Japan usually runs on 100 volts, not 110 volts. A fine thing to find out when you've got a wad of traveler's checks ready in a ham store in Akihabara. How do you make 100-volt equipment work on 110 volts?

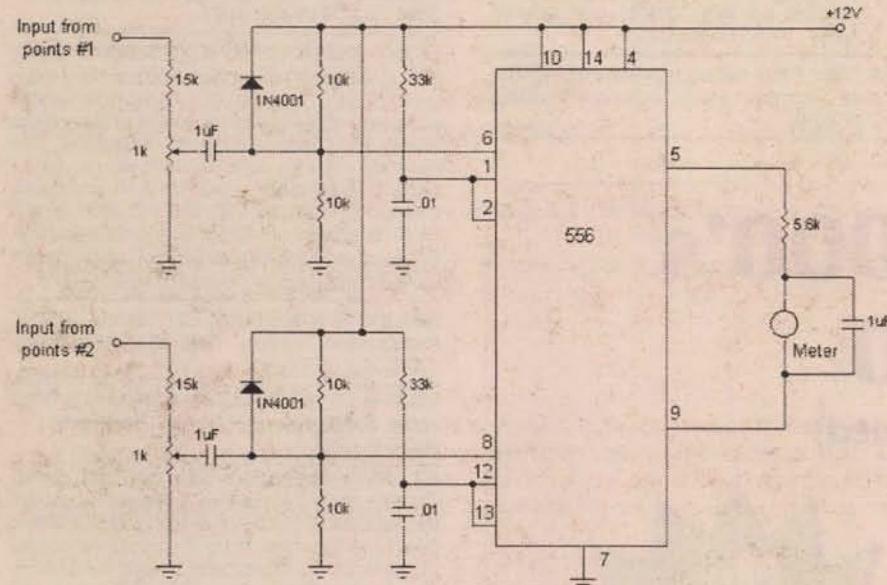
Jim Tolson  
via America Online

**A.** The world is divided into only two consumer voltages, 110 volts and 220 volts, neither of which are absolutes. If you look at the label of an appliance made for sale in the US, you'll see that it's actually listed as 120 volts (sometimes it'll say 115 or 117 volts). This means it'll work at any voltage between 90 volts and 130 volts. Why do we call it 120 volts, when Europe calls it 110 volts, and Japan calls it 100 volts? It has to do with the way power is distributed. During heavy usage periods, the line losses are high, and the voltage is down by as much as 10 percent, somewhere around 100 volts. Late at night, when we're asleep, there's hardly any load on the lines, and the voltage creeps up to about 125 volts. So, you pick a number, any number, between 100 and 125 and you'll be correct.

### Rev It Up

**Q.** I need a circuit that takes a pulse from the ignition coils of two gas engines and feeds a null meter that registers zero when the engines are running at the same RPM. The pulse conditioning part of this circuit isn't required.

Gordon N. Sutherland  
Shoreline, WA



**A.** This is actually a simple request if I read your question right. What I've devised is a pair of one-shot multivibrators that feed the meter in a balanced circuit. Basically, each multivibrator provides an average output voltage that's proportional to the RPM of its respective engine. When both output voltages are equal, that's when both engines have the same RPM, the meter should read zero. Realize that the 0.01 uF capacitor and 33 K resistor are critical to the balance, and you should buy them from the same source at the same time for best match. You may even have to adjust their values to bring the voltages within range for your particular application. The Vcc voltage (+12V) isn't critical, but it

Continued on page 114

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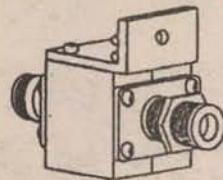
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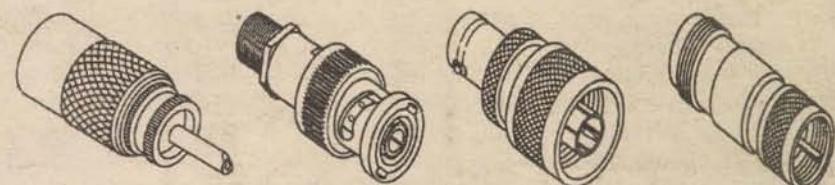
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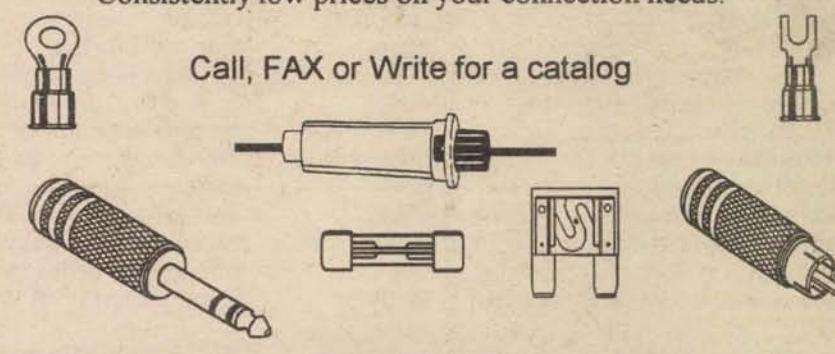
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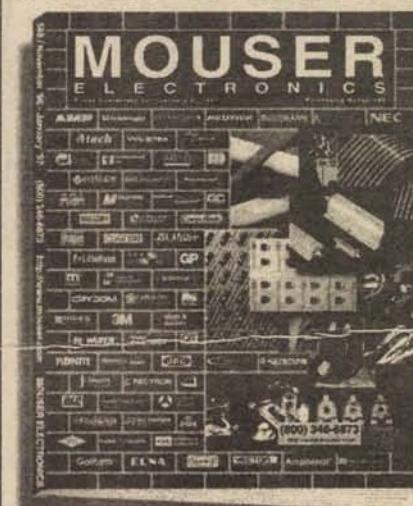
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# A

lmost all newer ham radios and marine single sideband transceivers offer at least 100 channels of user-programmable memory. This list of 100 popular high-frequency frequencies has been compiled by mariners sending in their reports on what frequencies they tune in most when out at sea, or near the US, Canadian, and Mexican coastlines.

All marine channels should be tuned in upper sideband. It is only the amateur radio service that uses lower sideband emission on 40-meter, 80-meter, and 160-meter bands.

The time signals and shortwave broadcast frequencies are best tuned in using AM, double sideband. This will yield a full fidelity sound when signals are strong. However, during weak signal reception on shortwave frequencies, you may wish to switch from double sideband AM over to upper sideband to improve reception. You will need to carefully tune the dial in order to zero-beat the annoying carrier sound.

The weather facsimile signals are tuned in upper sideband, and the frequencies listed for these weather facsimile channels has already been compensated for the 1.9 KHz offset. Simply tune them in upper sideband, dialing in the exact frequency listed. A simple lap-top computer and a weather FAX decoder/cable assembly from **Software Systems Consulting (714-498-5784)** is all you need to pull in weather facsimile imagery from your high-frequency worldwide radio.

Ship-to-ship marine channels are simplex; and as we mentioned before, all are upper sideband. Simplex means same transmit and same receive frequencies.

However, ship-to-shore channels such as the high seas marine operator and the United States Coast Guard are duplex. Reception is on the higher frequency, and ship transmitting is on the lower frequency. These are also upper sideband, and transmitting on these frequencies must be in compliance with FCC rules found in Part 80.

The handful of two-meter frequencies listed for "ICOM 706 only" are specific to this particular radio. The ICOM IC-7026 is the only worldwide amateur transceiver available that not only covers all of the worldwide high-frequency bands, but also offers transmit and receive capabilities on amateur six meter, 50 MHz frequencies, and amateur radio two meter, 144 MHz frequencies. This set also tunes in an incredible 200 KHz through 199 MHz, making it an excellent VHF scanner radio.

For radios other than the ICOM IC-706, memory channels 74 through 79 are available for any frequency of your choice.

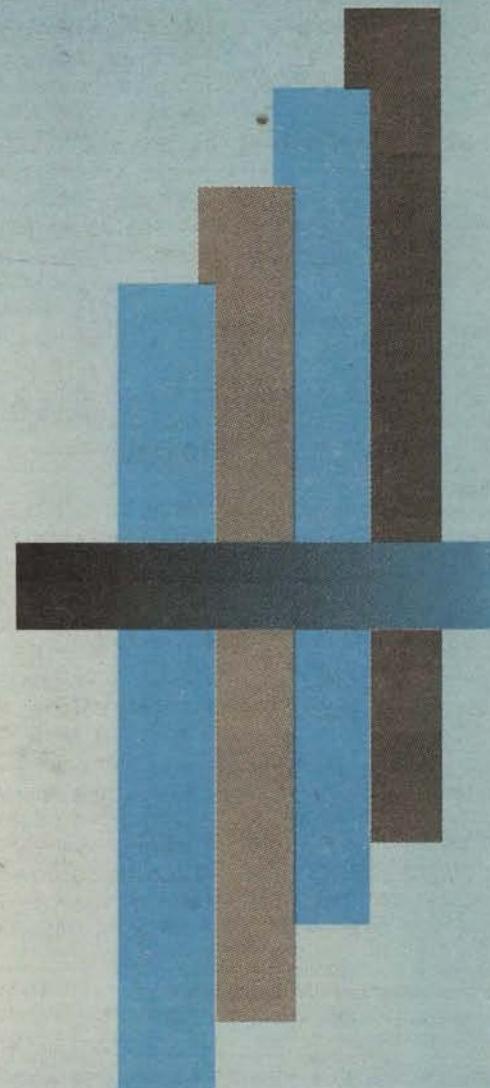
Memory channel 49, CB channel 14, is used in Mexico by shore boat operators. This is a handy one to have aboard.

The 24-hour maritime mobile frequency 14,313 KHz is best used by Pacific Coast mariners in the late afternoon and evening hours to communicate throughout the Pacific and South Pacific. 14,313 KHz is best ignored during the morning hours due to undisciplined radio traffic having little value to maritime mobile operators.

For daily ham radio news reports on 20 meters, try tuning in 14,275 KHz for the K1MAN amateur bulletins. You will hear some lively commentaries. To tune in the official bulletins of the American Radio Relay League, try tuning in 14,290 KHz for their early evening and late night transmissions. Tune 7290 KHz lower sideband for possibly better reception of nighttime ARRL transmissions.

Excellent Morse Code practices are found at the bottom end of each ham band. Try tuning to 7, 10, or 14 MHz, and then slowly increase the frequency in 1 KHz steps to locate some interesting code practice. You can also tune in Morse Code on the weather FAX channels in between regularly scheduled radio facsimile transmissions. The code speed is 15 WPM.

This list is for everyone's use and may be duplicated. We are always looking for corrections, changes, and additional interesting frequencies to tune in while out at sea. Send us your information to: **Gordon West WB6NOA, 2414 College Drive, Costa Mesa, CA 92626. NV**



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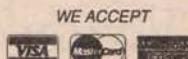
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## "WEST 100" MARINE MEMORY CHANNEL LIST — 1997

MCh	FREQ. KHz	INFORMATION ABOUT THIS FREQUENCY			
00	3815	Ham weather, Caribbean, early mornings	48	(17640) 21450-21850 (21470)	17 MHz/16-meter band
01	3968	Ham weather, West Coast, early am/pm	49	27,125	21 MHz/13-meter band
02	3930	Ham weather, Puerto Rico	50	2182	Citizens Band Channel 14
03	3964	Ham weather, East Coast waterway net	51	4125	Marine, international distress & calling
04	7230	Ham weather, Caribbean	52	6215	Coast Guard short-range
05	7237	Ham weather, Caribbean	53	8291	Ship-to-ship, 4S, short-range safety
06	7268	Ham weather, East Coast waterway net	54	12,290	Ship-to-ship, 6S, short-range safety
07	7238	Ham weather, Baja early am net	55	16,420	Ship-to-ship, 8S, medium-range safety
08	7294	Ham weather, Baja early am/pm	56	4060	Ship-to-ship, 12S, long-range safety
09	14,313	Ham maritime mobile freq. 24 hours	57	4051	Ship-to-ship, 16S, very long-range safety
10	14,340	Ham, West Coast "Manana" net at noon	58	8103	Ship-to-ship, Baja short-range
11	14,300	Ham, maritime intercontinental net	59	3023	Ship-to-ship, Baja short-range
12	21,400	Ham, Atlantic & Pacific long range	60	4146	Ship-to-ship, search and rescue
13	21,325	Ham, long-range crossings	61	4149	Ship-to-ship, 4A, short-range
14	28,400	10-meter Novice maritime mobile hangout	62	4417	Ship-to-ship, 4B, short-range
15	5000	WWV time and WX, night	63	6224	Ship-to-ship, 4C, daytime short-range
16	10,000	WWV time and WX, days	64	6227	Ship-to-ship, 6A, medium-range
17	15,000	WWV time and WX, days	65	6516	Ship-to-ship, 6B, medium-range
18			66	8294	Ship-to-ship, 8A, long-range
19			67	8297	Ship-to-ship, 8B, long-range
20			68	12,353	Ship-to-ship, 12A, long-range
21	4344.1	Pacific weather facsimile	69	12,356	Ship-to-ship, 12B, long-range
22	8680.1	Pacific long-range weather FAX	70	12,359	Ship-to-ship, 12C, Atlantic "Herb" weather reports
23	12,728.1	Pacific long-range weather FAX	71	16,528	Ship-to-ship, 16A, very long-range days
24	11,088.1	Pacific/Hawaii weather FAX	72	16,531	Ship-to-ship, 16B, long-range
25	16,133.1	Pacific/Hawaii weather FAX	73	16,534	Ship-to-ship, 16C, very long-range
26	9980.6	Pacific/Hawaii weather FAX	74	144.330 MHz	ICOM 706 only - mariner's 2m simplex
27	10,863.2	Atlantic Norfolk weather FAX	75	146.940 MHz(-)	ICOM 706 only - popular repeater
28	12,748.1	Atlantic Boston USCG weather FAX	76	146.820 MHz(-)	ICOM 706 only - popular repeater
29	8502	Gulf weather FAX, USCG New Orleans	77	145.220 MHz(-)	
30	12,787	Gulf weather FAX	78	(1A) 147.090 MHz(+)	ICOM 706 only - popular repeater
31	17,146.4	Gulf daytime weather FAX	79	162.550 MHz	ICOM 706 only - popular repeater
32	8078.1	Atlantic weather FAX		(no TX)	
33	15,957.1	Atlantic weather FAX		Telco & Coast Guard	Marine VHF weather channel 1
33	9108.1	Atlantic weather FAX	80	Tel CH 416	West Coast & Mexico
34	6338.6	Boston weather FAX	81	Tel CH 804	4402 RX, 4110 TX
35	13,282	Voice, aeronautical tower weather	82	Tel CH 809	8728 RX, 8204 TX
36	13,270	Voice, aeronautical tower weather	83	Phone	8743 RX, 8219 TX
37	8843	Aeronautical, including some weather	84	Home Tel CH 1201	Tel CH 822 8782 RX, 8258 TX
38	5547	Aeronautical, plus some weather	85	Tel CH 1203	13,077 RX; 12,230 TX
39	13,300	Aeronautical, including some weather	86	Tel CH 1229	13,083 RX; 12,236 TX
40	4750-5060 (4915)	5 MHz/60-meter band	87	CG424-Dist.	13,161 RX; 12,314 TX
41	5950-6200 (5975)	6 MHz/49-meter band	88	CG816-Dist.	4426 RX, 4134 TX
42	7100-7300 (7435)	7 MHz/41-meter band	89	CG1205-Dist.	8764 RX, 8240 TX
43	9500-9905 (9575)	9 MHz/31-meter band	90	Tel CH 403	13,089 RX; 12,242 TX
44	11650-12050 (11835)	11 MHz/25-meter band	91	Tel CH 802	4363 RX, 4071 TX Miami marine operator
45	13600-13800 (13760)	13 MHz/22-meter band	92	Tel CH 810	8722 RX, 8198 TX Miami marine operator
46	15100-15600 (15120)	15 MHz/19-meter band	93	Tel CH 814	8746 RX, 8222 TX Miami marine operator
47	17550-17900		94	Tel CH 825	8758 RX, 8234 TX Miami marine operator
			95	Tel CH	8791 RX, 8267 TX Miami marine operator
			96	Tel CH 1206	8809 RX, 8285 TX Miami marine operator
			97	Tel CH 1208	13,092 RX; 12,245 TX Miami marine oper.
			98	Tel CH 1209	13,098 RX; 12,251 TX Miami marine oper.
			99	Tel CH	13,101 RX; 12,254 TX Miami marine oper.
					13,119 RX; 12,272 TX Miami marine oper.

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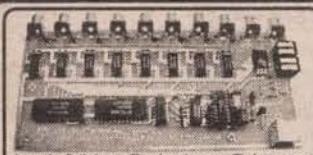
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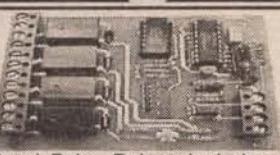
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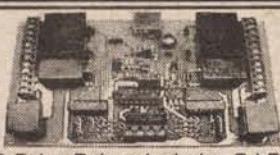
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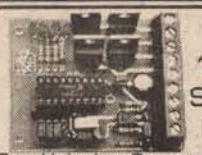
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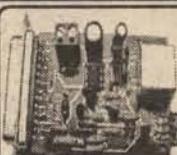
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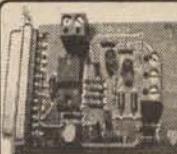
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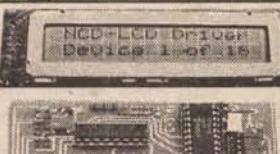
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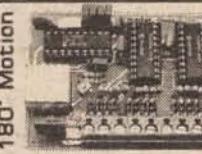
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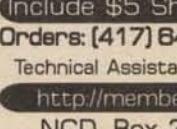
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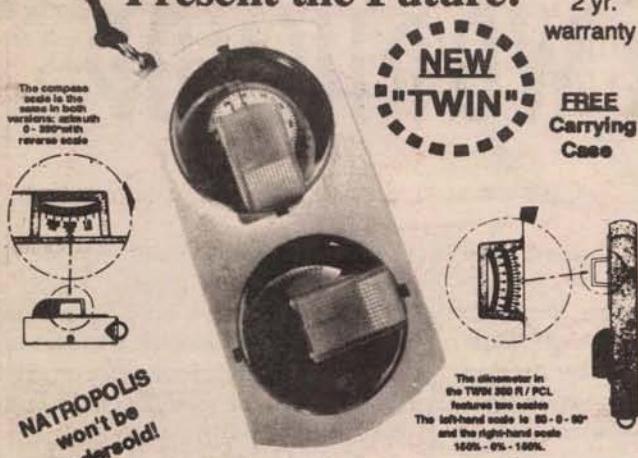
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\$11.95 each for Epson MX/FX-100/286e, LQ1000/1050, LQ2500/2550/EX800/1000/LQ860, AP3250/LQ100 Star NX1020/2400/2410/2415/2420, Panasonic KX-P 2180/2123/2124/1624/1524, Toshiba P321/351/1340. \$5.95 each for Okidata 82/92/83/93, Gemini 10X/15X.

Available in **BLACK** only at \$10.95 each for Star NX1000, NEC P2200, Commodore MPS-801.

Available in 4-Color Heat Transfer for Imagewriter II, \$12.95; Star NX1000 \$14.95; Star NX1020 \$23.95; Star NX2420 \$23.95; Star NX2450 \$23.95; Citizen GSX-140 \$23.95; Epson LQ2500/2550/EX800/1000 \$16.95; Fujitsu DX2100/2200/2300/DL 3300/3400/3600 \$27.95; Panasonic KX-P 2180/2123/2124 \$23.95.

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Nuts & Volts Magazine/November 1996 75

# THE NUTS & VOLTS SOLAR WORKSHOP

Welcome to The N&V Solar Workshop ...

**N**ot since the gas crunch of 1974 have I seen as much interest in solar power as I have in the last few weeks. My mailbag shows that many readers are curious about the technology, and more than a few of you want to put it to practical use. So, I guess it's time to open up "The N&V Solar Workshop." Let's step in.

Inside this virtual classroom/workshop, you'll find all kinds of nifty solar gadgets and activities. To the left, you see Bob adding solar power to his satellite dish. Amy, in the middle there, is discussing photovoltaic theory with Chad, while Raj (way in the back) has his solar-powered robot turning cartwheels. As you can see, The N&V Solar Workshop is full of fun and surprises.

Over the next few months, we'll explore the fascinating world of photovoltaics — electricity from light. Rather than bore you with dry details, though, I will demonstrate the workings and principles of solar electricity through hands-on construction projects. The projects will range from amusing toys to serious power systems. Don't get me wrong, there will also be plenty of theory. But while the two will run concurrently in the same article, they'll be separate so that the tinkerer doesn't have to wade through the theory to get to the fun stuff, and the student won't have to separate the nuts from the volts.

Enough said, let's get started ...

## THE WORKSHOP

Since Christmas is just around the corner, I thought we'd start with a couple of simple projects that are appropriate for this time of the year. Both projects are directly solar powered; that is, they don't use any batteries — simply a photovoltaic panel. This means that when the sun goes down, the lights go out. Photovoltaics only generate power, not store it. I'll address the issues of battery storage in the next installment of The N&V Solar Workshop.

Because both projects are intended for use indoors, we'll be using amorphous silicon cells, which are more responsive to artificial lighting and more tolerant of shading. While the following projects list specific photovoltaic devices from just two suppliers, you can substitute any solar generator with similar characteristics and ratings.

### Solarized Christmas Wreath

The first project is a Christmas wreath with blinking lights. The circuit is shown in Figure 1. This is a very simple design that uses a solar panel to power an array of LEDs.

### About The Solar Cells

The solar panel, which is actually cut from a larger panel, is a rigid glass structure made by Solarex and sold by FlaxSun Power Co. of Denver, CO (\$15.00 postpaid). It generates six volts at 100 mA under normal outdoor lighting conditions (i.e., no heavy overcast or fog). On a sunny summer day, the output current can reach 120 mA. Inside the house, the output current drops to about 60 mA in a well-lighted room, such as a dining room or kitchen. The LEDs require only 50 mA and will operate on as little as 30 mA, so there's plenty of cushion. Remember that when it comes to photovoltaic power, the voltage is pretty much fixed; it's the current that fluctuates with the light level.

### How It Works

The LED circuit is unique in that it uses a special flasher LED to blink the rest of the lights. This LED combines an IC driver with a regular LED in a standard two-lead LED case. No external parts are needed,

unlike some other LED flashers, such as the LM3909 IC.

When the driver turns the LED on, it draws current; in the off state, hardly any current flows. By placing this blinking LED in series with a standard LED, they flash in unison. This is identical to the way the flasher bulb of a Christmas light string causes the whole string to blink — it simply turns the current on and off.

Because the blinking LED normally operates at about 50 mA, we can place up to six regular LEDs in line with it and still have them operate normally. The blinking LED comes in red or green, and is available from a number of sources, including Radio Shack.

The voltage requirement of the blinking LED is three volts, while that of the other six standard LEDs totals 1.3 volts, for a grand total of 4.3 volts. The voltage of the solar panel under a heavy load is five volts, so we have plenty of cushion here, too. The small dropping resistors (R1 through R6) are used to equalize voltage differences between the parallel LEDs. Without the resistors, the LED with the lowest operating voltage would hog the show and be the only one to light; the rest would remain dark. If you have only one LED in series with the blinking LED, a resistor isn't needed.

### Construction

Buy, make, or steal a wreath, fake or real, it doesn't matter. But before you do, decide where you want to place the four-by-four-inch solar panel. If you want it in the center of the wreath, you'll need one big enough to accommodate it (a wreath with a six-inch hole will do). However, there's nothing stopping you from

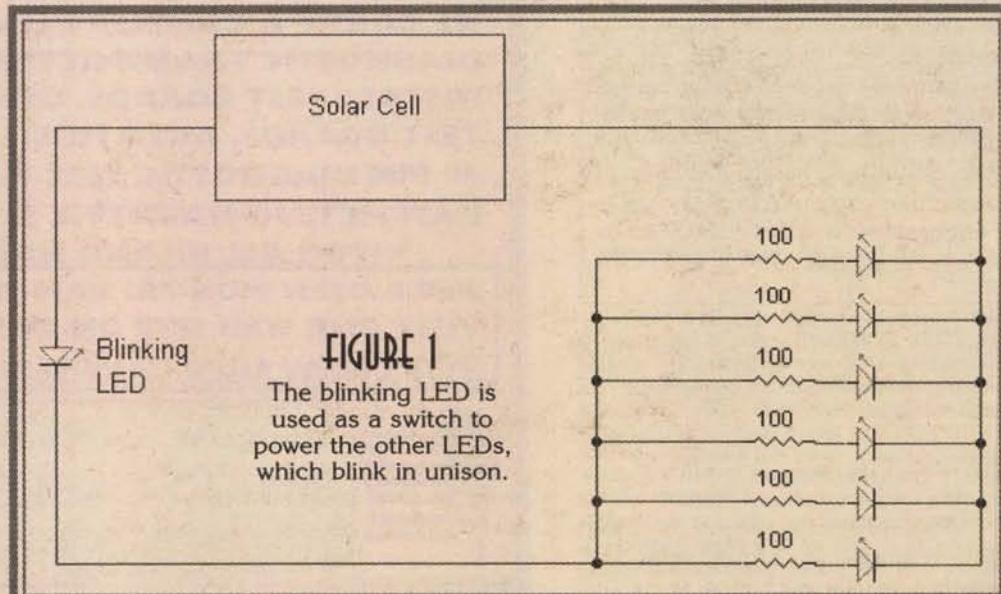
placing the solar panel outside the wreath in another location, such as directly above it as I did (it prevents foot traffic from blocking the light and makes the panel look like an additional ornament when oriented in the diamond position).

Now decide where you want to place the flashing lights. There are seven in all, which can lend itself to some interesting combinations. The blinking LED will be the brightest, so take that into consideration. To each lead of the LED, solder a wire long enough to reach the solar panel by any route you wish. Just make sure you can identify the positive leg from the negative leg when they arrive.

The connection point is a printed circuit board which is glued — copper side out — to the back of the solar panel. The solar panel is made of thin glass, which makes it rather brittle, so the circuit board serves as both a support and a junction box. A foil pattern of the circuit board is shown in Figure 3. You can use any of the fancy shmancy techniques they have to transfer this pattern to the board or, better yet, use a permanent marker pen to draw your own reasonable facsimile. There's nothing critical here. In fact, you don't even have to etch the board. A Dremel tool will mill out the copper islands nicely.

Resistors R1 through R6 are soldered on the clad side of the circuit board before the solar panel is attached. Once the resistors are in place, use a good permanent adhesive to bond the board to the solar panel. Double-sided tape is not a good answer, and epoxy is overkill. Properly cured rubber cement (read the label) works quite well, and is removable with thinner, if necessary.

At this point you can continue any way you want. Install the lamps



# THE NUTS & VOLTS SOLAR WORKSHOP

first, then solder the leads to the junction board, or solder the LED wires first and place the lamps afterwards. I've discovered that the latter route makes for less work and a tighter wire bundle, but it's your choice. It's not important which lamp goes to which resistor, they're all the same, just get the polarity right. The solar panel's leads are soldered to their indicated points, as are the blinking LED's wires. Now expose your handiwork to the light of day and enjoy solar power the good old-fashioned Yuletide way.

## A Mobile Christmas Mobile

This idea came from a devoted fan of mine, my girlfriend. Like many of you, she has a growing collection

the realm of solar cell types. Because of its wireframe construction, the loads are unpredictable, making rigid glass solar panels out of the question. Any tugging or pulling on the mobile's wires could crack or dislodge a glass solar panel.

The solution is an amorphous-on-stainless cell which can withstand the twisting and turning. These cells are often used in marine (boat) applications where whipping winds and salt water spray quickly end the life of anything that doesn't bend like a willow. No oak trees allowed. The cells are from Gateway Electronics of St. Louis, MO. They are rated two volts (open circuit; 1.5 volts under load) at 350 mA and cost \$5.95 each (\$4.95 each if you buy 10 or more).

## How It Works

As you recall, my girlfriend and I agreed on a rotating mobile. If you've never seen a mobile, it's a dynamic display akin to Chinese wind chimes, which are precariously balanced and driven by air currents. In this case, I've eliminated the wind and sound effects, and replaced them with rotational motion, which means I

When you connect the solar cells to the clock movement's battery terminals, the clock runs, which causes all three output shafts to turn at different speeds. By securing the mobile to the shaft of your choice (the hour hand has the most torque), you have a cheap, low-speed drive motor. Before you squawk and say how can such a small mechanism pull such a heavy load, note that the clock is mounted horizontally, not vertically as it normally is, so it has gravity working for it, not against it.

There are three solar cells altogether, placed on the superstructure 120 degrees apart. All three are wired in parallel, not series. This isn't done to increase the output current (the clock movement couldn't use in one year what one cell generates in a day), but to eliminate the effect of changing light conditions as the mobile spins (this is an old satellite trick). As one solar cell sails off into the "sunset," another is in position to catch the "rising sun" (Figure 4; top view). Consequently, the revolving cone is never out of contact with a light source if it exists, which keeps this nerdy thing going, and going, and ...

## Construction

The superstructure is made out of coat hangers shaped into hoops of varying sizes that are held together with vertical struts which are soldered in place. A pretty coat of paint covers most blemishes, and texture is added (a handful of sand) before the paint dries to keep the hooks from sliding back and forth on the slick wires. My girlfriend and I differed on how the mobile should be shaped, and for good reason. A mobile is a work of art, and to that extent beauty is in the eye of the beholder. I guess I must be an engineer and she an artist, because I wanted to put the big hoop at the top so that the topmost ornaments would overhang those on the bottom without hitting them. She said the "thing" should have the shape of a Christmas tree, not a drippy faucet. Well, she won, but not because of that.

Because the solar cells are attached to the superstructure, so must be the clock. Otherwise, you'd have a hard time getting the wires to the battery terminals without ending up in a tangled mess after a couple turns. Putting the smallest hoop at the top makes it easier to attach this "birdcage" to the clock's plastic case. It also makes it easier to clamp on the shaft of your choice, clock face point upward, and secure it to the ceiling.

Yeah, I guess I'm an engineer. However, I encourage you to use your own judgment as to how you think

the superstructure should look. If I were to do it again, I'd try a widening-at-the-bottom spiral. Just leave room enough for an unobstructed view of the three two-by-six-inch solar cells. By the way, you don't have to mount them vertically as I did; they're flexible and will fit the other direction, too. That said, feel free to express your artistic side. Who knows, we may have a budding Alexander Calder in the audience.

## THE CLASSROOM

Okay, class, let's settle down. This will be a lecture, so I expect you to pay attention and take notes because I won't repeat myself and there will be a quiz at the end of this session. This month's topic is on the types of photovoltaic cells, and their applications. First, I'll start with a brief history of photovoltaics, and rapidly move into modern day use. The key point (pause: let me hear those notepads rustling) is: Who's who in the solar power industry? Let's begin.

Although most of us are unaware of it, solar electricity has been around for more than a century. Its effects were first observed by Alexander Edmond Becquerel (noted physicist and father of Henri Becquerel, the discoverer of radioactivity) in 1839. As part of a series of electrical experiments, he immersed two metal plates into a conductive solution and exposed the entire apparatus to sunlight. Much to his surprise, a small voltage was generated.

This finding went largely unnoticed until 1873, when Willoughby Smith discovered a similar effect after exposing selenium to light. Although his first experiments were crude and inefficient, they represented the actual birth of the solid-state solar cell.

But the concept of electricity from sunlight was put on the back burner for nearly 100 years. It wasn't until the early 1950s when Bell Laboratories, in search of a new power source, rekindled interest in photovoltaics and invented the crystalline silicon solar cell, which is the mainstay of today's modern photovoltaics.

But again, the dream was laid to rest until 1983, when ARCO Solar (now Siemens) built a one megawatt plant in Hesperia, CA next to Southern California Edison's Lugo substation and tied it into the power grid. A year later ARCO Solar built a six megawatt solar power station in Carrisa Plain, CA (Figure 2). Unfortunately (or fortunately, if you're looking for cheap second-hand solar panels), both sites have been dismantled and the solar panels are being sold off as surplus. Fortunately, solar power still flourishes in places like the Netherlands, Guam, and New Age/Survivalist pockets of rural

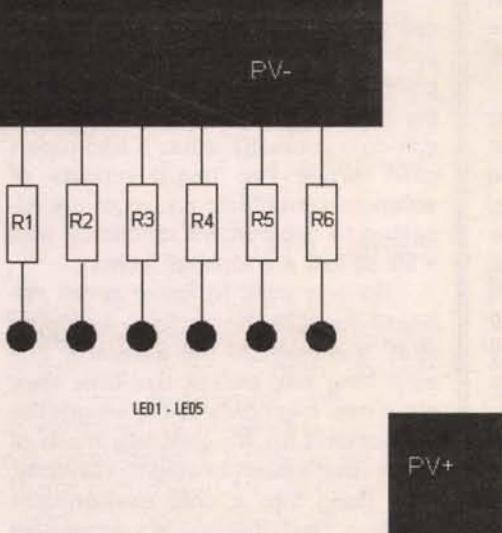
FIGURE 2

The ARCO Solar site at Carrisa Plain, California.



FIGURE 3

Printed circuit board for the wreath "blinking lights" project. The board is not to scale, and you can easily do your own with a magic marker, like the kind found in a Radio Shack PC Board kit (276-1576).



of cool Christmas ornaments, and keeps adding more as the years go on. But last year even her humongous "Audrey II" houseplant couldn't handle the spillover from the Christmas tree. Something had to give. She proposed hanging them from the ceiling. I suggested, "If we're gonna do that, let's put them on a motorized mobile. That way you can showcase them." We agreed. Little did she know I planned to make it solar powered so that I could move it about without a tethering power cord.

## About The Solar Cells

This project's unique construction requires a unique solar cell, which gives us a chance to explore

needed a really slow-speed motor to keep the trinkets from flying off the hooks.

After spending a lot of time digging through the parts catalogs trying to ferret out a gear-reduction motor that met all my power needs, I ran across a battery-powered clock movement. You know, the kind that runs off a single-cell battery for a whole year. Bingo! Not only did it meet my power requirements by a long stretch, it also netted me a choice of rotation options: once a minute, once an hour, or twice a day. You can buy these gems in any hobby store or through the mail for about \$8.00, or recycle one from that ugly clock Aunt Martha gave you for Christmas last year.

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# THE NUTS & VOLTS SOLAR WORKSHOP

## Solar Cells

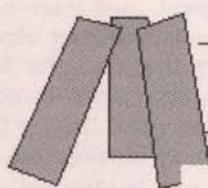


FIGURE 4

For the solar mobile we use three solar cells placed on the superstructure 120 degrees apart. This is an old satellite trick. As one solar cell sails off into the "sunset," another is in position to catch the "rising sun."

Top View

Northern California.

At about the same time as ARCO's big solar push, Solarex, a veteran in solar energy, made its move into the alternative power systems market. Their first large-scale use of photovoltaics was to convert their Frederick, MD production facility from utility power to solar power. They placed their first solar panels off the assembly line on their own roof, not somebody else's. They remain a major supplier of polycrystalline PV cells.

It's time to make a distinction between ARCO's crystalline solar cells and Solarex's polycrystalline solar cells. Crystalline solar cells, often referred to as "CZ," are made from a single silicon crystal. The crystal is grown in a high-temperature tank into a long cylinder, about six inches in diameter, which is later sliced into wafers. This is the same type of silicon used to make the Pentium microprocessor and other chips in your computer. A polycrystalline solar cell, most generally referred to as "amorphous solar cell," consists of many crystals. As its name implies, it's not a single crystalline structure, but a bunch of crystals that occupy a common space. You can spot an amorphous solar cell right off the bat by its straw-like pattern.

Amorphous solar cells are cheaper to make than CZ cells because they're shapeless and you don't have to go through the laborious process of growing an elegant crystal. Single crystals are grown by slowly pulling a seed crystal from a vat of molten silicon. The temperature and pull rate must be precisely controlled to produce a perfect crystal. The rate of pull is very slow, something on the order of one inch an hour, which is why the process is so costly: time is money.

Amorphous silicon, in contrast, is silicon that's been melted and just left to cool, like a loaf of bread. Both are crystalline: one is a single crystal, the other consists of polycrystals.

Because of its disciplined organi-

zation, CZ solar cells are more efficient than amorphous solar cells. Typically, a CZ solar cell operates with 15 percent efficiency, whereas an amorphous cell struggles to attain an 11 percent efficiency ratio (efficiency is defined as the potential amount of sunlight in to the power out).

Both CZ and polycrystalline come out as loaves which have to be sliced into wafers. This is accomplished using a diamond-toothed saw blade, which makes sawdust — actually silicon dust — which means a lot of material is lost in the process. In an effort to reduce waste and cost, the industry has come up with a technology called "thin-film." Basically, thin-film solar cells are amorphous solar cells on glass. A pane of glass is first placed inside a plasma furnace, and silicon (along with other needed ingredients) is sputtered onto the glass. It was thought, at one time, that thin-film solar cells could be as efficient as CZ or poly. Nice try, but after a decade of development, they still only rate about five percent efficiency.

Moreover, thin-film solar cells seem to have a shorter life span than either CZ or amorphous when exposed to the elements of sunlight and heat. The best that thin-film can muster is five years; most lose half their power after just two years service. However, thin-film does have its advantages. It's very responsive to fluorescent lighting, which makes it the perfect power source for calculators and other office gadgets.

So, when you build this photovoltaic into an office environment, away from the harsh elements of the outside world (sunlight, heat, etc.), you can expect your solar-powered calculator to outlive you. CZ cells, on the other hand, don't mind the cold, and can live as long as 30 years in the outside world. Amorphous cells are almost as good, but they die sooner, usually after 10 to 20 years.

A fairly recent development has been flexible photovoltaics. Essen-

tially, it's thin-film placed on a stainless steel backing. Unlike the cells described previously (which are all glass-based) they don't break when you bend them. Moreover, the metal backing seems to add something to the recipe, because these solar cells have a slightly higher efficiency than plain thin-film and they seem to last longer.

Just so that I don't leave you hanging, there are a few more types of solar cells out there, most of which

you'll never even see. So what do you care? Who knows, maybe someday you'll grow up to be a rocket scientist and need to know this stuff.

The most prominent contender is gallium arsenide (GaAs) solar cells. These babies have set a world record for efficiency. Most check in at 25 to 30 percent, and a few have achieved 50 percent efficiency with a concentrator. What's a concentrator? A big lens, a telescope if you will, that focuses the sunlight onto the cell. Unfortunately, they're expensive and seldom found outside Sandia Laboratories' proving grounds.

The cadmium sulfide (CdS) solar cell arrived very early on the scene, and was the forerunner of solar power. While cheap to make (it's simply a paste on a metal backing, you can do it yourself), it has a bad report card. While I've heard reports of seven-percent efficiency, most are relegated to two-percent efficiency with a life of just a couple of years.

So you want to know about ribbons? Just like the package wrapping stuff, it comes off the assembly line as a long roll, except this time they cut it into segments of the length the project calls for. It's generally made of silicon that's been heated to elasticity, then flung into a cold environment where it flash-freezes. It's expensive and mostly experimental at the moment, but it could be a happening thing if we ever build a "really" working space station.

Texas Instruments has created what's called the spherical solar cell. Unlike a flat solar cell, the spherical solar cell looks like a flying saucer, fatter in the middle and thinner at the edges (Figure 5). The spherical cell consists of many tiny spheres of silicon coated with aluminum foil to provide electrical contacts. It's a simple manufacturing process that uses low-cost, low-purity silicon feedstock material. Efficiency levels on TI modules have been measured at greater than 10 percent. While that's nothing to write home about, it may have future potential. TI began developing Spherical Solar in 1983 and is current-

ly looking for a buyer for the technology. Southern California Edison has shown some interest, but no plans have been announced. Definitely keep your eyes on this sleeping giant.

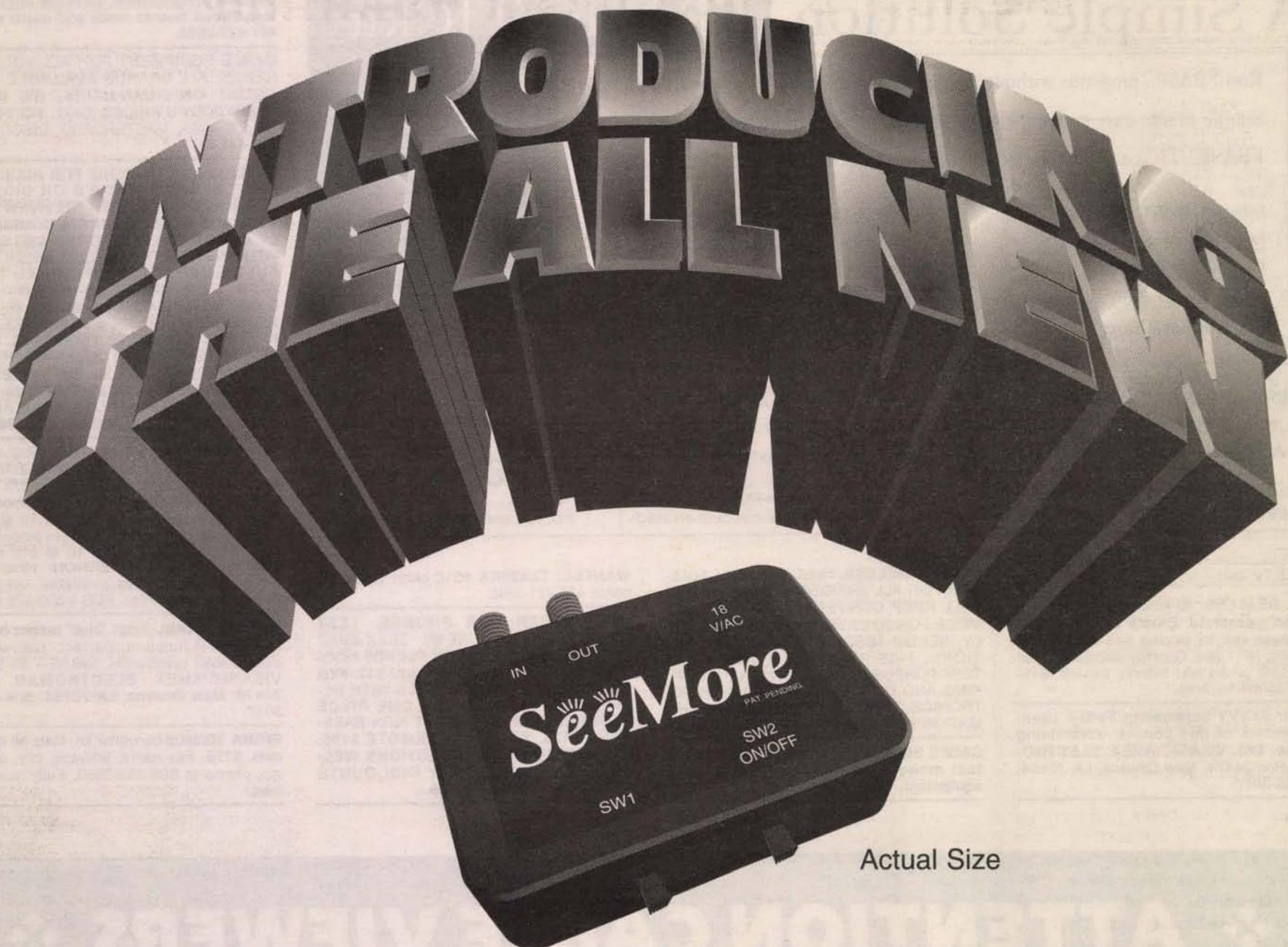
What else is there in this magical photovoltaic hat? Well, there are multijunction solar cells. Multijunction photovoltaic cells employ multiple layers of semiconducting materials to create two or more junctions. Different layers in the cell absorb different frequencies of the solar spectrum, so the overall efficiency of the cell can be high. Then there are hybrid or stacked solar cells that mix the high efficiency of gallium arsenide with silicon. The theory here is that the red light that the GaAs cell misses is absorbed by the silicon cell directly beneath it, which gives the sandwich a 5 to 10 percent boost. It works, but it's very expensive. Lastly, I've seen reports about scientists in France (and thereabouts) who are experimenting with plastic photovoltaics. It's been a while since I've heard anything on this technology, though, so who knows what's happening on that front.

And that concludes today's lecture. On your way out, pick up a copy of the quiz and hand it in at next class. Dismissed. NV

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## QUESTIONS

- 1) Who discovered photovoltaics? Who invented the solar cell? Are they one and the same?
- 2) Name the two types of solar cells likely to be found in the marketplace today?
- 3) What type of solar cells are used in office calculators?
- 4) How do solar cells differ from photovoltaic cells?
- 5) What is the overall efficiency range of solar cells? What's typical for an amorphous cell?
- 6) How long do solar cells live?
- 7) Why do they die?
- 8) Name the element(s) used in the first successful solid-state solar cell. Name the element(s) used in today's working (i.e., practical) solar cells — more than one type, please.
- 9) What is a fuel cell?
- 10) How do CZ solar cells differ from amorphous solar cells? Who makes which, and name two jobbers that sell them.
- 11) Where would you find a thin-film solar cell, and would you put it into your application? (Explain why.)



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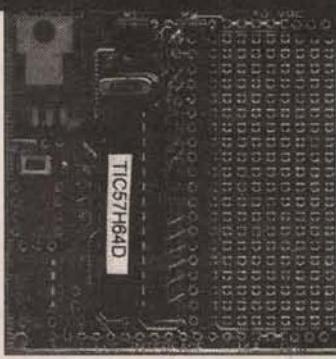
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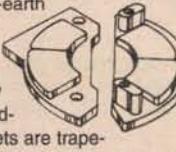
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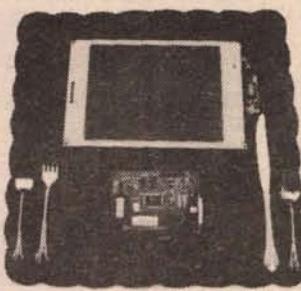
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# RESOURCE BIN

number fifty eight

## Getting a charge out of batteries

**O**ur usual reminder here that the *Resource Bin* is now a two-way column. You can get tech help, consultant referrals, and off-the-wall networking on nearly any electronic, *tinaja questing*, personal publishing, money machine, or computer topic by calling me at (520) 428-4073 weekdays 8-5 Mountain Standard Time.

### A Look at Batteries

Take a fresh lemon and stick a bare copper wire and an iron nail into it. Now connect a voltmeter between the wire and nail and you should observe a voltage. Switch to an ammeter, and watch for a few mils of current.

#### Lemon power.

This is one simple example of an *electrochemical cell* which is often and wrongly called a *battery*.

Just as that original battery was a grouping of cannon, your electrical battery is supposed to be a *group of cells*. A normal flashlight is supposed to have *one battery* of *two cells*. But nearly everybody says "battery" when they mean "cell."

An electrochemical cell consists of an *electrolyte* through which ions can freely find their way between any two dissimilar conductors. An *anode* at the positive terminal and a *cathode* at the negative terminal. At one time, these electrolytes had to be liquid. But these days, you will find gels, pastes, and even a few solid electrolytes.

When an external circuit is closed, a current results. Caused by a chemical reaction that forces electrons from the (-) *cathode* on over to the (+) *anode*. As that electrical energy in your current gets "used" externally, the amount of chemical energy remaining in the cell decreases. Thus, *discharging* the cell.

A *primary battery* is normally a one way sort of thing. It starts with a high-chemical energy and usually is able to discharge only once.

Some examples of primary batteries are carbon zinc flashlight cells, higher current alkaline cells, small mercury or silver oxide cells for long life at rather low currents, and brand new long life, high-current lithium cells.

Any secondary battery is reversible. You can initially charge it by "filling" it with electrical energy. Energy that is converted into higher levels of stored chemical energy. You then *discharge* it into a load as needed.

One common secondary battery is the *lead acid* battery you'll find in any automobile. Other secondary batteries include *nickel cadmium* and *nickel metal hydride* cells used for everything from cordless phones to toothbrushes. And *lithium polymer* variants.

You may find quite a bit of overlap between primary and secondary cells. Some flashlight cells can be recharged a few times. With less bang for your buck each time. Those secondary cells cannot get recharged forever. They'll typically have a *useful lifetime* of a few hundred to several thousand charge and discharge cycles.

Every battery technology trades off energy density, lifetime, cost, current levels, temperature, terminal volt-

### NEXT TIME: Don reveals insider secrets for starting up your own tech venture.

age, discharge properties, rechargeability, convenience, and safety.

### A Closer Look

A lead-acid battery is made from a sulphuric acid electrolyte solution, a lead cathode, and a lead oxide anode. To discharge your battery, an external current is drawn. Reversibly forcing lead, lead oxide, and sulphuric acid into lead sulphate and water. Thus reducing the stored chemical energy.

To charge your battery, an external current is applied. Reversibly forcing the combination of lead sulphate and water back into lead, lead oxide, and sulphuric acid.

Thus raising the available chemical energy to higher levels.

Somewhat similar reactions do exist for all popular battery chemistries. No one battery is "best"

for all uses. So a dozen or more choices of chemistry are popular today.

There's several important measures of how "good" a battery is. These are collectively called the *energy density*.

This energy density sometimes gets expressed by *weight*. Telling you how heavy your battery has to be.

While *watt hours per kilogram* is the norm, *watt hours per pound* will often get used instead. Note that there are 2.2 pounds in a kilogram.

If your energy density is expressed by *volume*, it tells you how big or how bulky the battery has to be. While *watt hours per liter* is the norm, *watt hours per cubic inch* or a *watt hours per cubic centimeter* might sometimes get used. There are 61 cubic inches or 1000 cubic centimeters in one liter. A liter is also called a *cubic decimeter*.

As a rule of thumb, the watt hours per liter will be *two or three times* the watt hours per kilogram. For typical chemistries most of the time.

For instance, some alkaline primary cell may offer you an energy density of 140 watt hours per kilogram or 400 watt hours per liter. A nickel metal hydride cell might provide an energy density of 65 watt hours per kilogram or 170 watt hours per liter.

In general, a primary battery can deliver longer life for a given weight and volume. But at less convenience and higher operating costs.

My fire pager can barely make it overnight without having to recharge its older NiCads. But it easily goes for several days on alkalines. And more than two weeks on lithium.

Here are some battery resources ...

### Duracell

The *Duracell* folks have lots of free battery brochures. These can get you educated in a big hurry. Included are lifetime discharge curves and full tech specifications.

Let's review what you'll find in a few of these brochures ...

**Carbon Zinc** cells are in those plain old primary flashlight batteries. While the cheapest of the lot, they are not really as cost-effective as the newer choices. Typical energy densities are 50 watt hours per kilogram or 150 watt hours per liter.

By the way, an old caver's trick on flashlight cells: Always reverse to top cell in your backup light source. That way nothing awful happens when it inevitably turns on in your pack.

**Alkaline Manganese Dioxide** cells are a newer and a better substitute for carbon zinc. The high costs are more than offset by longer life and fewer surprises. These are really

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# RESOURCE BIN

## SOME BATTERY TECHNOLOGY RESOURCES

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<b>Benchmark</b> 2611 Westgrove Dr #101 Carrollton TX 75006 (214) 407-0011	<b>Electrochemical Society</b> 10 S Main St Pennington NJ 08534 (609) 737-1902

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<b>Varta Batteries</b> 300 Executive Blvd Elmsford NY 10523 (914) 592-2500
<b>Yuasa-Exide</b> 645 Penn Street Reading PA 19601 (215) 378-0333

great for flashlights, toys, and intermittent high-current loads. Energy densities are as high as 140 watt hours per kilogram or 400 watt hours per liter.

The **Mercuric Oxide** or **Silver Oxide** battery systems are typically offered as tiny coin cells. They are usable for computer real-time clocks, watches, or calculators. The output voltage is very stable and flat. Energy density is 110 watt hours per kilogram or 450 watt hours per liter.

Mercury cells are being phased out because of safety and toxicity.

**Zinc Air** cells are a safer and newer primary replacement for the mercury cells. These unusual cells have an *air access hole* in them. They are best used for continuous, but low, currents. They also do not self-discharge until the air seal is removed.

Since one of the products "used up" in a zinc air cell is external, they have a big time energy density advantage. Namely 350 watt hours per kilogram and a stunning 1200 watt hours per liter. But note that these are suitable for small and light loads only. They are unlikely to end up very useful for electric vehicles.

**Nickel Cadmium** secondary cells are one of the earliest of rechargeables. These still remain popular today for test equipment, toothbrushes, and in some cordless appliances at 40 watt hours per kilogram or 120 watt hours per liter, but with some bad habits.

Cadmium is a deadly heavy metal and is tricky to properly dispose of. Certain NiCads have a *memory effect* where if you lightly discharge them all the time, they will forget entirely what a deep discharge is.

Note that typical NiCads have an extremely low internal impedance. If you short-circuit one, an exceptionally high current is quite likely. Possibly exploding the cell. And welding both shorted and shorter.

**Nickel Metal Hydride** secondary batteries are a big improvement over NiCads. With higher energy densities and safer chemistry. They largely lack NiCad's undesirable memory effects. Important uses include laptops, video cameras, and cellular phones.

The new primary **Lithium** cells are often the "best." Outstanding life gets combined with superb energy densities and higher per cell voltages.

But prices are still way high.

Lithium is by far the lightest metal and is plentiful in sea water. Sadly, lithium is extremely reactive and has been a bear to tame for battery use.

Some lithium technologies are now reaching 400 watt hours per kilogram and 1000 watt hours per liter.

Watch out for new rechargeable and extremely lightweight *lithium polymer* cells from Argonne and others.

Interestingly, these apply a "warm" technology that has to hold the cells at 60 degrees C or so. A good review of lithium polymer possibilities appear in the Sept. '96 *Automotive Industries* on pages 75-77.

One source for specialized custom high-efficiency lithium cave lighting devices is *HDS Systems*.

### Yuasa-Exide and Panasonic

Ordinary **lead-acid** batteries use a wet chemistry. One which has to get maintained, ventilated, and remain right side up. A *gel cell* instead uses a gelled electrolyte. These normally are usable in any position and are sealed from the environment.

Gel cells are often used for alarm systems, for emergency lighting, and for uninterruptable power supplies. Their typical energy densities are 25 watt hours per kilogram and 60 watt hours per liter. Cheap, but not so great compared to newer cells.

Uh, *Duracell* is not in the lead acid business. Instead you'll have to go to *Yuasa-Exide*, to *Johnson Controls*, or to *Panasonic* for the gel cells. These are usually stocked by *Mouser*, *Digi-Key*, and all of the usual suspects.

Additional ads for battery suppliers are found in the *EEM Master*. And in *E.E. Times*, *Electronic Component News*, and similar trade journals.

### Get a Charge Out of This

Newer rechargeable cells are quite fussy over how you charge them. You can't simply shove a bunch of current into them and blithely walk away.

The latest of charger circuits will use pulse techniques. Which carefully measure cell voltage and temperature. Important suppliers for the intelligent charger chips now include *Benchmark*, *Unitrode*, and *Dallas*.

A review of charger resources can be found as my file HACK80.PDF on [www.tinaja.com](http://www.tinaja.com)

You can expect the next generation of batteries to have some degree of built-in intelligence. A thermistor at the least. Maybe even a full micro to provide both safety and "gas gauge" functions. *Amp* is a leading proponent of new multi-pin battery connectors that ease adding smarts to these next-generation power sources.

### The Battery Reference Book

This fat textbook by T.R. Crompton is sold by *Butterworth Heinemann*. All of the major battery technologies are exhaustively covered in depth.

Lead acid, nickel, silver, alkaline, carbon zinc, zinc chloride, mercury, lithium, manganese dioxide, sodium sulphur, metal air, zinc halogen, and scads of others.

The second edition was revised

in 1995. The text is British, so you'll see some European emphasis. Plus a few rough spots in the translation. As an example, they'll use cubic decimeters instead of liters in their notation.

One electrochemistry publication is *Interface*. Edited by the *Electrochemical Society*. In the area of trade groups, you should find an *Independent Battery Manufacturers Association* and a *Battery Council International*.

And, of course, the web is crammed to the gills with online battery info.

### 1-800-BATTERIES

There are several newer outfits that now specialize in one-stop shopping for all replacement battery packs. For video cameras, cellular phones, and laptop computers. You should find ads for many of these in *Nuts & Volts*.

One high profile supplier is *Power Express*, who have a 1-800-BATTERIES catalog. Two competitors are *Battery Technology* and *B&H Photo Video*.

### Home Power

As we've seen a time or two before, *Home Power* magazine is the source for most alternate energy topics.

Including, of course, the batteries used for most solar and wind energy storage. You'll find lots of advertisers, tech info, and detailed reviews.

I've provided a hot link to the home power web site on [www.tinaja.com](http://www.tinaja.com) – Yet another source for home energy battery storage products is *Real Goods*.

### Electric Car Batteries

Most of the heaviest trucks and the most powerful locomotives found in the world today are electric. And have been so for decades. Thus, your key problem is making electric cars more wimpy, not less.

There's been great heaping bunches of hidden secret agendas, regulatory hassles, market uncertainties, lack of infrastructure, and the misdirection in most auto battery research.

Do note that the energy density of gasoline is ridiculously higher than any known battery technology. When all is said and done, gasoline today is a "better" choice by a factor of nearly one hundred. This is your main reason electric cars have yet to make it very far out of the driveway.

Until batteries dramatically improve, a hybrid car having a small constant speed diesel engine, a limited battery set, and not less than four in-wheel motors makes the most sense to me.

But today's laptops, cellphones, and

## RESOURCE BIN

video cameras form an instant and a baggage free new multi-billion dollar market for new battery technology.

A fresh market that demands energy densities far in excess of that needed for an automobile. Thus, your laptop computer aftermarket industry will shortly and certainly "solve" the key electric car problem.

Your leading resources on electric car batteries include SAE, EPRI, and Automotive Industries. The best take on alternate hybrid vehicles is available from the Rocky Mountain Institute.

Many homebrew electric car topics also appear in *Home Power*. And in RESBN51.PDF on [www.tinaja.com](http://www.tinaja.com)

### A Challenge

Is there any battery research you can do on your own?

For decades now, there has been a perpetual motion scam eeking out a meager existence on late night talk shows. In several cases, exceptional battery life extensions are claimed. In a system that involves high voltages, sudden inductive switching, and "lots of sparks."

Life extensions which occasionally disappear when you place a diode in series with the cells. Could there be a real effect hidden in the hype?

While, of course, remaining within the bounds of physical and chemical reality. And the real world.

Theoretically, if so much as a scrap of the zinc case still remains on an ordinary flashlight cell, recoverable energy remains. Such a cell does not "run down" by fully depleting all its chemical energy. Instead, processes involving polarization will gradually increase the cell's internal resistance to the point where useful energy can no longer be drawn.

Life curves tell us that discharging such a cell only a few hours per day gives much longer life than running it continuously. Those electrochemical "cells" used by the electroplating folks often are reversed every now and then. Purposely unplating a tad. For cleaner and smoother results.

What happens if you recycle some part of the drawn energy as narrow and high current spikes? Say a reverse ten amps for a twentieth of a second every five seconds. Against a normal half amp draw.

One amp second back for five out.

Because of inherent nonlinearities, this pulsed return current just might depolarize better than a continuous draw can polarize. Possibly, a longer battery net life could result.

Conceivably, you could have this electronic disk that snaps on top of the top cell of your flashlight. A disk that magically extends battery life by discouraging polarization.

The big bucks question that you can personally explore today is whether such a recycle effect exists at all. Casual observation says it should. And if this effect exists, is it cost-effective enough and dramatic enough to bother with?

A BASIC Stamp project, obviously. Switching with a power Mosfet. And some PC data acquisition. And always fresh cells from identical lots inside the same package.

Limit your experiments to carbon zinc or alkaline cells only. Don't even think of trying this with NiCads! Just to stay on the safe side, use a "bomb shelter" consisting of a paint can full of sand. And some fuses.

Fixed resistor heating loads are a much more controllable choice than a nonlinear light bulb filament. A good digital voltmeter is a must.

What can you come up with here?

### This Month's Contests

Let's have two contests this month. Tell me about a battery resource I am not familiar with. Or run

that pulse recycling experiment to see if you can come up with a useful result.

There will be a largish pile of my new *Incredible Secret Money Machine II* books going to the dozen or so better entries, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two that will go to the very best of all.

Send all your written entries to me here at *Synergetics*, rather than to *Nuts & Volts* editorial. NV

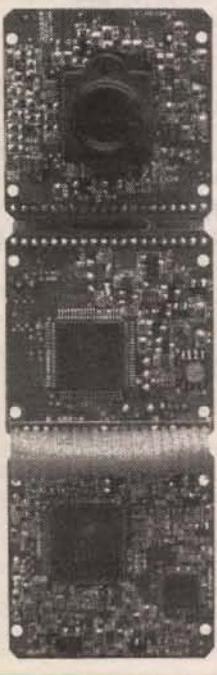
**M**icrocomputer pioneer and guru Don Lancaster is the author of 33 books and countless tech articles. Don maintains his no-charge US tech helpline found at (520) 428-4073, besides offering all of his own books, reprints, and consulting services. Don also has two free catalogs full of his resource secrets waiting for you. Your best calling times are 8-5 on weekdays, Mountain Standard Time.

Don is in the process of setting up his Guru's Lair at <http://www.tinaja.com>

Full reprints and preprints of all Don's columns and ongoing tech support appear here. You can reach Don at *Synergetics*, Box 809, Thatcher, AZ 85552. Or send any messages to his US Internet address at [don@tinaja.com](mailto:don@tinaja.com)

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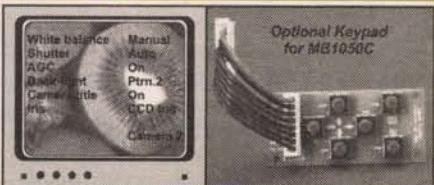


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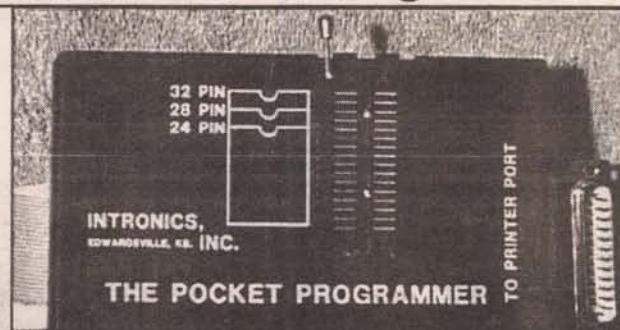
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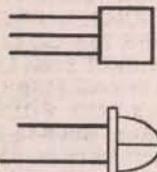
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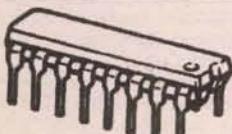
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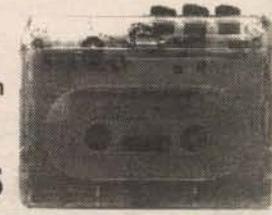
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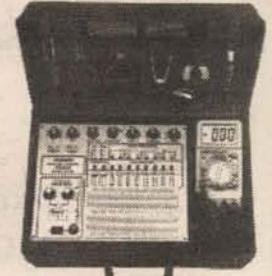


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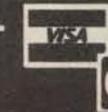
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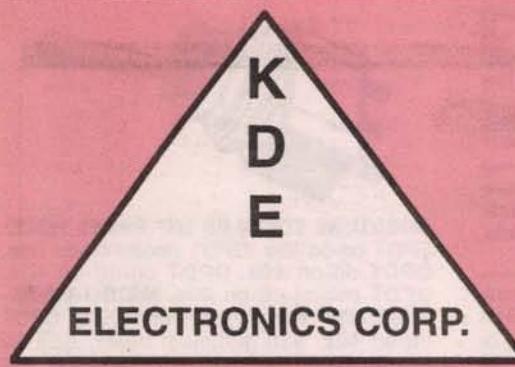
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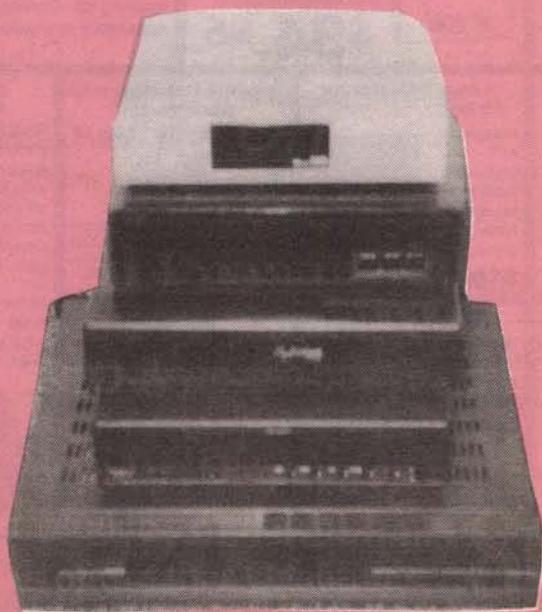
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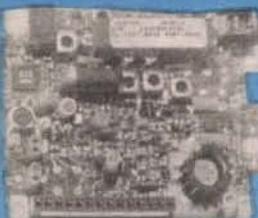
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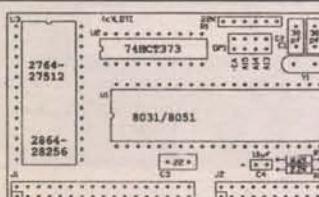
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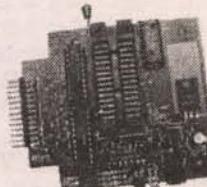
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NUTS & VOLTS MAGAZINE  
NEW PRODUCT EDITOR,  
430 PRINCETON CT., CORONA, CA 91719

## E-METER



Cruising Equipment Company announces a series of hardware and software enhancements to its E-Meter product line.

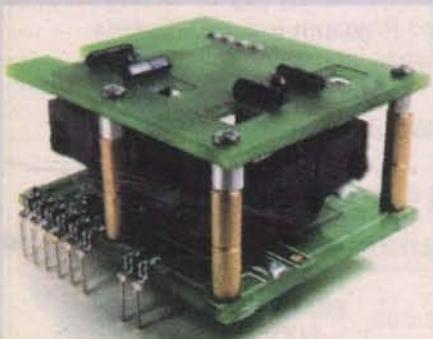
Key among the new features is an input for active battery temperature sensing. When used with an optional external temperature sensor, battery temperatures from 0-99C are considered. The E-Meter also allows the user to declare a temperature coefficient for the batteries being monitored.

The enhanced E-Meter also features a two level visual low battery alarm. The E-Meter senses both extended low-voltage conditions and rate compensated low-battery capacity.

For more information, contact:

**CRUISING EQUIPMENT COMPANY**  
5245 SHILOH AVE. NW.,  
DEPT. NV  
SEATTLE, WA 98107  
206-782-8100 FAX: 206-782-4336  
E-MAIL:  
<http://www.cruisingequip.com>

## VECTOR 2XG



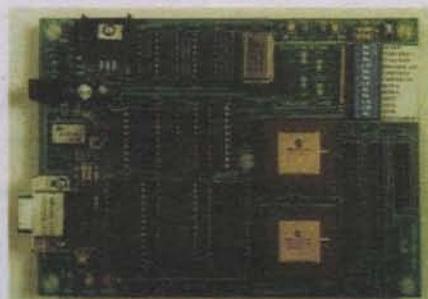
Precision Navigation announces the release of the Vector 2XG, the newest product in the Vector series of low-cost two-axis compass modules.

The Vector 2XG is a two-axis magnetometer-based system with mechanically gimballed sensors. The gimballed sensors allow the Vector 2XG to be tilted up to  $\pm 15$  while remaining accurate to within 2°. The Vector 2XG outputs either compass heading or uncalibrated magnetic field readings via a three-serial wire output format, which is compatible with Motorola SPI and National Microwire.

For more information, contact:

**PRECISION NAVIGATION, INC.**  
1235 PEAR AVE. #111, DEPT. NV  
MOUNTAIN VIEW, CA 94043  
415-962-8777 FAX: 415-962-8776

## PICEM-14 DOWNLOADERS



MicroSystems Development announces the PicEm-14 downloader development board. The PicEm-14 is a real-time emulator that operates just as the programmed device would, this is not a simulator! The approach is simple, develop the code and send the HEX file over a serial link and the code starts to operate! Use your favorite communications program or the included utility PC program to download the code. PicEm-14 accepts all standard Intel Hex format files so you can use your favorite assembler or download one from our WEB site.

For more information, contact:

**MICROSYSTEMS DEVELOPMENT**  
4100 MOORPARK AVE. #104,  
DEPT. NV  
SAN JOSE, CA 95117  
408-296-4000 FAX: 408-296-5877

## PORTABLE 12-BIT DATA ACQUISITION

Base<sub>2</sub> Computer Corporation announces the availability of two new products for its DACQ-25 product line. The new DACQ-25/12 data acquisition module offers an increase to 12-bits analog sampling resolution over the existing

# News

10-bit DACQ-25/10 module. Complementing both modules is the new DACQ-25/BB signal breakout box which gives convenient sensor hook-up via terminal strips. Additionally, the DATAQ software package has been extensively modified to include direct disk data logging and a programmable controller that eliminates the need for most custom applications.

The DACQ-25 data acquisition modules can either be purchased individually or in combination with the signal breakout box (BBX-25). The DACQ-25 packages, which also include cable and manual, are priced starting at \$99.95. The DACQ-25BB packages which include the breakout box are priced starting at \$135.95.

For more information, contact:

**BASE<sub>2</sub> COMPUTER CORPORATION**  
P.O. BOX 950, DEPT. NV  
PASADENA, CA 91102  
818-583-5525

## KEELOQ® ENCODERS/DECODERS



Microchip Technology, Inc., introduces the HCS360 and HCS361 advanced KEELOQ® code hopping encoders and the HCS509 and HCS512 single-chip KEELOQ decoders.

Designed to exceed the rolling code PKE system requirements for leading automobile OEMs, the HCS360/HCS361 encoders feature added error detection using a two-bit cyclic redundancy checking (CRC) and a secure learn protocol through transmission of an extended 48-bit seed along with the high-security algorithm and features offered by the other KEELOQ encoders.

These devices eliminate the need for firmware development and reduce hardware development which shortens normal system design time and provides faster time-to-revenue. The HCS509/HCS512 are the only turnkey single-chip decoders which support KEELOQ encoders and provide on-chip EEPROM for the non-volatile storage of decryption keys.

For more information, contact:

**MICROCHIP TECHNOLOGY, INC.**  
2355 W. CHANDLER BLVD.  
DEPT. NV  
CHANDLER, AZ 85224-6199  
602-786-7200 FAX: 602-899-9210

## FIELD SERVICE SOLDERING



The Antex Model G/3U miniature soldering iron heats up and recovers instantly and operates from 115 VAC for in-plant or field service use, while the Model MLXS 12-volt soldering iron is powered by any standard 12-volt automotive or marine battery. For optimum thermal efficiency, their heating elements are directly under their tips.

The Antex Model G/3U miniature soldering iron sells for \$19.95 (list) and the Model MLXS 12-volt iron sells for \$34.65 (list).

For more information, contact:

**M. M. NEWMAN CORP.**  
24 TIoga WAY, P.O. BOX 615  
DEPT. NV  
MARBLEHEAD, MA 01945  
617-631-7100 FAX: 617-631-8887

## ICOM R8500 COMMUNICATIONS/SURVEILLANCE RECEIVER



ICOM and SWS Security announce the new R8500 communications/surveillance receiver.

A few features of the new R8500 are: full frequency coverage of 100 KHz to 2 GHz, built-in RS-

## New Products

232 computer control port, built-in tape recorder controller, 12 VDC or AC power, video receive capability with optional TV-R7100, extremely high receive sensitivity for maximum range with low-powered surveillance transmitters, TCXO for lab grade frequency stability and accuracy, 1,000 memory channels, and an eight character alpha nametag on each channel. An aftermarket spectrum display screen also is available exclusively from SWS.

For more information, contact:

**SWS SECURITY**  
1300 BOYD RD., DEPT. NV  
STREET, MD 21154-1836  
410-879-4035 FAX: 410-836-1190  
1-800-SPOT CRIME

### NECK LIGHT



An adjustable position lamp, supported by a comfortable neck bank; it floods the darkest project or area with an abundance of brilliant, shadow-less, color balanced halogen light. No heavy, bulky transformer is needed. A flexible 11-foot cord provides ample freedom of movement, and a quick disconnect permits you to leave the work area without unplugging the cord. The bulb life is over 1,000 hours nominally, and the entire cover is sturdy fiber glass. The unit runs cool and is safe to use. Lamp angle is adjustable and quickly locked into the desired position, where it remains without slipping or moving.

The introductory price is \$104.00.

For more information, contact:

**NECK LIGHT COMPANY**  
2290 W. HICKS RD. #35-2  
DEPT. NV  
FT. WORTH, TX 76131  
817-439-1910

### SHOWBIZ-5000P

Wedge Technology, Inc., announces a unique modular multi-media presentation notebook PC that touts the ability to put the unit on an overhead transparency projection machine. It is a new, powerful, and effective tool for a professional to run live presentations.

ShowBIZ-5000P is a combination of a projection panel, a powerful workstation, and a notebook PC all in one.

The ShowBIZ-5000P is a fully powered notebook PC available with 10.4" active super VGA display screen with a removable back cover. Once the back cover is slid out, the WEDGE ShowBIZ-5000P screen can be placed on a standard overhead projector. A large, high-resolution image of the PC data (text or VGA graphics) can thus be projected on a blank wall or on a beaded screen.

For more information, contact:

**WEDGE TECHNOLOGY, INC.**  
1657 MCCANDLESS DR.  
DEPT. NV  
MILPITAS, CA 95035  
408-263-9888 FAX: 408-263-9886  
1-800-872-9334  
<http://www.wedgetech.com>

### MAG-PROBE



Jensen Tools offers two models of an inexpensive test probe for troubleshooting controller-operated electrical and electronic equipment.

The Mag-Probe determines the polarity and condition (energized or de-energized) of solenoids, reed relays, coils, valves, stepper switches, and micro-controlled equipment — without the need of an electrical connection, or any physical contact with sensitive components.

For more information, contact:

**JENSEN TOOLS, INC.**  
7815 S. 46TH ST., DEPT. NV  
PHOENIX, AZ 85044  
602-968-6241 FAX: 602-438-1690  
1-800-426-1194

### LPT:ANALOG! V2.0



ADNAV Electronics announces ALPT:Analog! v2.0, a low-cost 12-bit analog-to-digital adapter for the PC parallel printer port. This adapter is a very simple and convenient interface for acquiring analog signals directly on a PC at rates of up to 7,500 samples per second. Signal

conditioning information is supplied making it easy to collect data from analog-output instruments, sensors, 4-20 mA loops, and many other analog signal sources.

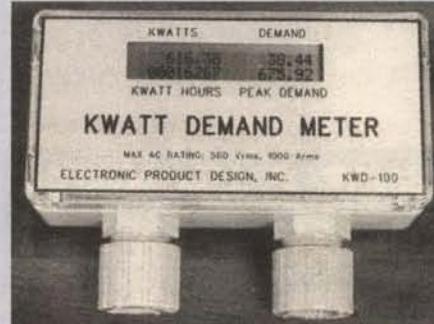
LPT:Analog! v2.0 is supplied with software utilities that enable real-time display of acquired waveforms, ASCII-format data logging to disk, as well as high-resolution spectral analysis of acquired data. The source code (QBASIC, C, and assembly) for these utilities is included at no extra cost. In addition, software drivers, VisualBasic DLLs, and programming examples are also provided.

The LPT:Analog! v2.0 adapter sells for \$59.00.

For more information, contact:

**ADNAV ELECTRONICS**  
58 CHICORY CT., DEPT. NV  
LAKE JACKSON, TX 77566  
409-292-0988

### KWD-100 DEMAND METER



The KWD-100 Demand Meter is an electronic instrument used to measure power and demand of electrical loads operating from 50 or 60 Hz power. This Demand Meter can measure one or two phases of current referenced to a single voltage. It is housed in a NEMA-4 enclosure and can be permanently mounted. The KWD-100 can be used on circuits up to 600 volts and with currents to 1,000 amps. Measurements provided include peak-demand, peak-demand-time, present-demand, present-time, kilowatts, and kilowatt-hours. All values are available to the operator via a front panel LCD. Isolated output options include RS232 serial transmission, or analog outputs suitable for driving a chart recorder.

The KWD-100 Demand Meter is a new product and the price is \$386.00.

For more information, contact:

**ELECTRONIC PRODUCT DESIGN, INC.**  
6963 BLUEBELLE WAY  
DEPT. NV  
SPRINGFIELD, OR 97478  
1-800-616-5521

### CODE FLASHER

The Lanz Company Code Flasher is intended to aid those that have a hearing impairment. Passing your

five-word-per-minute code test will give you the privileges above those that have only passed the TECH no code.

The Code Flasher will light an LED in sink with the code that would be heard normally through the speaker of a cassette player, allowing you to visually see the code as it is being sent from the tape in the cassette player.

Included with the Code Flasher is a lithium battery for longer life (can be easily replaced when it has run down), an audio tape for five to eight words-per-minute code with Random and QSO type messages, and a print out of all the code on the tape. By following the code on the print out and observing the flashing, a short flash for the (.) DIT and a longer flash for the (-) DAH, you can learn the code, and also check for accuracy. The QSO type messages will be similar to what you can expect when you go for testing.

The total retail price is \$44.95, plus \$5.00 S & H.

For more information, contact:

**THE LANZ COMPANY**  
3523 DAYTON AVE., DEPT. NV  
LOUISVILLE, KY 40207  
502-897-2468

### LOW-COST MICROCONTROLLER



National Semiconductor announces a family of highly integrated, cost-effective, one-time-programmable (OTP) eight-bit microcontrollers. The new COP8SAx family integrates many features found externally on most microcontrollers, making it a true complete system on a chip for eight-bit applications. The COP8SAx family saves designers printed-circuit-board (PCB) space, manufacturing, and passive component costs, while increasing reliability.

The COP8SAx offers full integration with internal R/C oscillator, internal power-on-reset (POR), internal pull-up resistors, internal Schmitt-Triggers, and internal protection diodes.

For more information, contact:

**NATIONAL SEMICONDUCTOR CORP.**  
2900 SEMICONDUCTOR DR.  
DEPT. NV  
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408-721-5000 • 1-800-272-9959  
[www.national.com](http://www.national.com)

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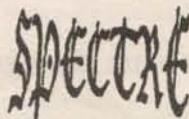
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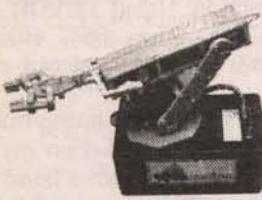
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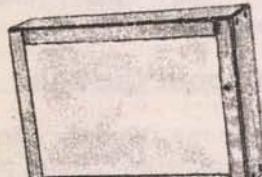


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by Karl Lunt

## Building a Dead-Reckoning Robot

The Seattle Robotics Society (SRS) runs several contests throughout the year, and one of the more unusual is the dead-reckoning (DR) event. The DR contest offers a formidable challenge using very few rules, and can be run with anything from a simple robot to a sophisticated machine. In this column, I'll take you through the contest rules and my design for a viable DR robot.

In running the dead-reckoning event, your robot must begin from a marked starting point on a flat surface. When the judge says "Go!", you start your machine on a prescribed, but unmarked, course. The course consists of a two-meter run forward, a 45-degree turn clockwise, then another two-meter run forward. The course's endpoint is marked for human recognition, though not for robot recognition. Your robot's performance is judged by how close it stops to the endpoint.

Your machine must carry a pointer or marker of some kind, so the judge can verify your robot's starting and ending position. Though not required, you will probably want to include some type of pointing or aligning mechanism, so you can properly align the robot at the starting point.

Some of the SRS machines have put in excellent performances, and any robot entered in one of these events had better hit the endpoint within 1/4" or it won't have a chance for first place.

Gearhead motors equipped with suitable encoders can perform very well in this event, but finding a suitable motor isn't easy. One of the most ingenious designs was fielded by Mark Casteluccio, who managed to embed quadrature encoders inside the housing of a Futaba R/C servo motor. His machine hit the endpoint with amazing accuracy; Mark's software even inserted a 360-degree pivot in the middle of the run, just to show off a bit. I've described a few designs for embedding encoders in these servo motors in previous columns; refer to past issues of *Nuts & Volts* for details.

But stepper motors remain the most obvious drive system for the DR event. I based my DR robot design on Bill Bailey's stepper motor driver boards, showcased in a recent column. Rather than duplicate that schematic here, I'll refer you to the July '96 column.

### The LM2595 switcher

My robot design uses a 12-volt gel-cell battery to supply power for the stepper motors. To drive the on-board electronics, I originally used a set of four C-cell Renewal alkaline batteries. The design worked, but I was never happy with the weight. It just seemed like too much bulk to supply the few milliamps needed by the 68hc11 BOTBoard and other circuitry. And the extra battery pack was, well, inelegant. I was about ready to drop in a Junk-Box Switcher when I ran across an advertisement in *Electronic Engineering Times* that provided the perfect answer.

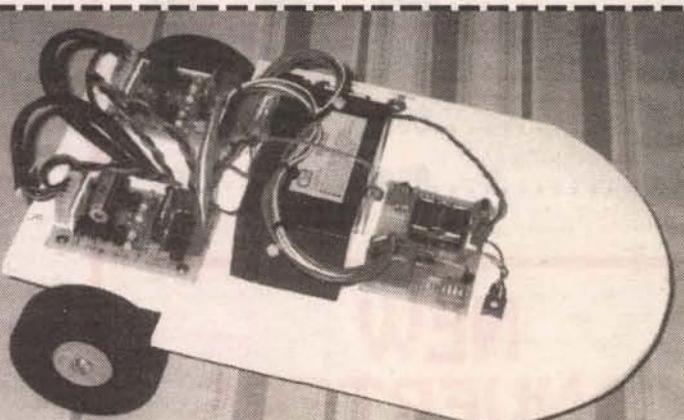
*EE Times*, as you can guess, caters to the electronics engineer, and carries a huge assortment of articles on high-end engineering topics. You can always find the latest skinny on new chips, new network protocols, new technology, new legislation

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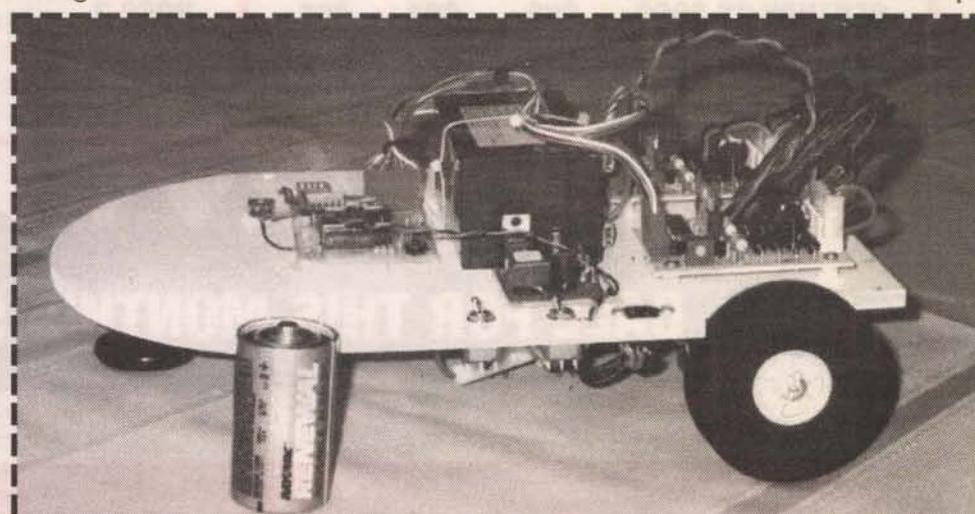
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But a major appeal to me is that the big chip vendors carry a lot of advertisements in *EE Times*, and sometimes they announce some real deals. For example, the August 26, 1996 edition ran an offer by National Semiconductor that was too good to refuse.



A shot of the DR robot, showing the two stepper control boards (left), the 12-VDC gel-cell battery, and the 68hc11 BOTBoard that drives the machine. I'm using 2-3/4" Dave Brown Lite-Flite wheels. The robot measures 12" long by 8" wide.



Here is a close-up of the robot, showing the two toggle switches for controlling power to the motors and the BOTBoard. The National Semiconductor LM2595 switching power supply sits between the switches and the gel-cell battery. To the right of the switches, I've added a power jack for charging the gel-cell. A D-cell in the foreground gives an idea of the robot's size.

National has long carried a great line of linear components, and every well-stocked designer's shelf should have a bunch of National Semi data and application books. Lately, National has been pushing devices such as the LM2595 switching power supply controller. This device comes in a five-lead TO-220 case, and forms the core of what National calls the Simple Switcher power supply. Using just this device, two capacitors, an inductor,

and a Schottky diode, you can build a switching power supply for converting anything from 7 to 40 VDC input down to 5 VDC output at up to one amp of current.

To entice engineers into trying the device, National offered to send readers a working power supply built with this chip, along with a pack of data sheets AND a floppy disc of design software, free. All you had to do was call National Semiconductor (800-272-9959 x606) and ask for a LM2595 demo package. I'm including the number here since the offer didn't show an expiration date.

My demo board arrived within a week, and I was impressed. The board measures only 1-3/8" by 1-1/2" and has a small male header for the few electrical connections needed. The switcher runs at

150 KHz and sports thermal shutdown and current limit protection. Using 12 VDC on the input, the LM2595 reaches 85% efficiency, which means you'll get the most out of your batteries.

The board doesn't have mounting holes, so I just placed it where I wanted it on my robot base, then fastened it down with a bead of hot glue on each of the PCB's corners. I soldered wires directly to the proper ground, voltage in, and voltage out pins, and even added a red LED and 820 ohm dropping resistor between ground and the output pin, as a power-on indicator.

One plus for this power supply was immediately apparent. I saved nine ounces of overall weight by using the switcher to replace the original set of four C-cell Renewal alkalines. I spend a lot of time on my designs trying to reduce weight, and dropping over half a pound with this PCB was a big win.

The National package includes a set of very complete data sheets for the LM2595 and other devices in the Simple Switcher family. Each data sheet contains a full range of graphs and design guidelines, to help you design your own switcher. You get tips on selecting the inductor and a list of recommended vendors. You even get a PCB layout, so you can build additional boards. This is a first-rate evaluation package and I really like the LM2595. Recommended.

### A bit about the base

I built my DR base using my favorite material, Sintra plastic. This is a foam-based plastic, available in sheets at most large plastic houses. By scrounging the scrap boxes at local stores such as TAP Plastics, I've built up a reserve of Sintra in assorted sizes and colors. I like using Sintra because even the 1/4"-thick sheets cut very easily, the material takes simple machining well, and you can even tap it for screws. To glue Sintra, use a free-flowing Acrylic cement, available from TAP Plastics or other large suppliers.

I cut my base to be 12" long and 8" wide, with a rounded front end and cutouts at the back to

accommodate inset wheels. I've pretty much standardized on the Dave Brown Lite-Flite wheels, a foam-type unit with two-piece Delrin snap-apart hub. The axle bore is exactly the right size to thread a #8 screw through, which, in turn, matches with the direct-drive wheel adapters that the SRS' Dan Mauch made for me. The wheel and adapter make a perfect unit for the business end of my 'bot.

I added my usual drawer knob as a front caster. I started with a large, black plastic knob. I then cut a piece of foamcore to a square about 1-1/2" on a side and drilled a 1/4" hole in the center of it. I ran the knob's screw through this hole, then into the knob, cinching the knob tightly against the foamcore. Finally, I used two pieces of foam tape to stick the knob and foamcore to the proper location on the underside of the robot's base.

### Fine-tuning the steppers

For motive power, I hooked up a couple of Vexta PXB44H-02AA steppers to my base. The Vexta motors are rated at 6 VDC, 800 mA, and provide plenty of torque for moving the base. I strapped the stepper driver boards for half-stepping, giving me 400 steps per revolution. I then wrote a small SBASIC program for providing a stream of pulses to the motors.

But when I turned on the power so I could talk to the BOTBoard's 68hc11 in bootstrap mode, the motors locked in place, then the 1.75 amp fuse I had installed in the power circuit popped. When the 68hc11 comes up in bootstrap mode, your software isn't running and you have no control over the I/O port lines. The stepper driver boards were getting full current and blowing the fuse before I could download my program and gain control of the lines.

This led to two changes. First, I installed a second SPST switch for the motor voltage, in series with the switch already used to control the power for the 68hc11. Thus, I could turn on the MCU, but leave the motors unpowered. Next, I reset the current control on both boards. I had originally set it for 500 mA per winding, which was over the fuse limit; it was also over the free-air dissipation rating of the L298 driver chips, so they would have gone into thermal shutdown, anyway. I trimmed the drivers for 200 mA per winding, which proved to be plenty of current for my needs.

But now a new problem surfaced, one that had me stumped for a couple of hours. The motors moved, but the motion was ragged and had little torque. At first I suspected a blown driver transistor in one of the L298 chips, but each driver board, run separately, worked fine, so the L298s were good. Finally, I got in touch with Bill Bailey and Dan Mauch, the club's main stepper experts. They got me headed in the right direction.

The L298 has an internal oscillator for timing operations with the stepper motor. You can run several L298s off of the same oscillator if you wire them together properly. You must first select a single L298 as the master, and disable the oscillators on all other L298s. This only involves tying pin 16 of each device to ground. Then, you simply wire the SYNC pins on all of the L298s together. This is pin 1 of the chip, or pin J2-2 on Bill's PCB.

My problem occurred because I had wired both of the SYNC pins together, but not disabled one of the oscillators. Since the oscillators on both boards were running, they would occasionally get out of sync, causing the ragged performance and reduced torque I saw. I simply tied one of the pin 16s to ground and both motors began running beautifully.

In tuning the steppers, I needed a quick and dirty way to vary the frequency of pulses my software issued to the stepper driver board. I could have used a serial port connection to the 68hc11's SCI and some SBASIC code to read incoming characters, but I chose instead to add a fob knob. The term comes from MIT's engineering labs, and refers to a general-purpose analog control or dial.

Given the 68hc11's eight A/D converters, adding a fob knob takes nothing more than a 10K-ohm trimpot between +5 VDC and ground, with the wiper hooked to one of the A/D input lines. At selected points in your software, you read the current value of the A/D channel, then convert the reading into the appropriate range and pass it to your test software.

In my case, I wired the fob knob to PE0. My conversion software translated the voltage on the A/D port into a pulse duration count, which then determined the step rate for the motors. The fob knob let me alter the step rate on-the-fly, smoothly and efficiently. A simple idea that can come in handy in many designs.

One last change to my system involved mounting the heavier components. I usually favor double-sided foam tape and hot glue; they are cheap and light, and they don't require great mechanical dexterity, a real plus for most software types. But this robot was going to get some rough treatment, and the bulky motors and battery

pulse rates that work better than others, and some pulse rates flat won't work at all. The major influences over stepper performance are the mechanical resonance and inertia of the system.

You can get a graphic demonstration of these influences by using the fob knob to vary the starting pulse rate for your motors. Beginning with a pulse rate of about 200 pulses per second, repeatedly start the robot from a full stop, increasing the step rate slightly each time. You will not only find an upper limit beyond which the robot simply won't move, you likely will also find a few settings in between where the motors chatter or skip a few pulses before starting. These intermediate settings correspond to resonances in the robot's mechanics, where the physical mechanics conspire to make the load on the motors appear greater than it really is.

You could try tracking down the various interplays in the mechanical elements, tightening here or loosening there, in an effort to remove (actually, change) the resonances. A simpler approach involves starting the pulses at a slow rate, then quickly accelerating the pulses until they reach the desired rate. This technique, known as ramping, can prove very effective in overcoming mechanical resonances. And since the solution lies in software, you can fine-tune your solution easily.

Note that you don't need a very complicated ramping algorithm to overcome even serious mechanical resonances. I once worked on a table-top device that used several steppers to move paper through a mechanism. The mechanism had some very nasty resonance problems, and the first — order solution — throwing in a bigger motor — wasn't available due to physical constraints.

But experimentation proved that a very simple ramping technique solved the problem. We ended up issuing four pulses at a slow frequency, four pulses at a faster rate, and issued the remaining pulses at the fastest, target rate. Those first eight steps, ramping from a slower rate up to the target rate, helped the steppers overcome the mechanical resonances and yielded very reliable performance.

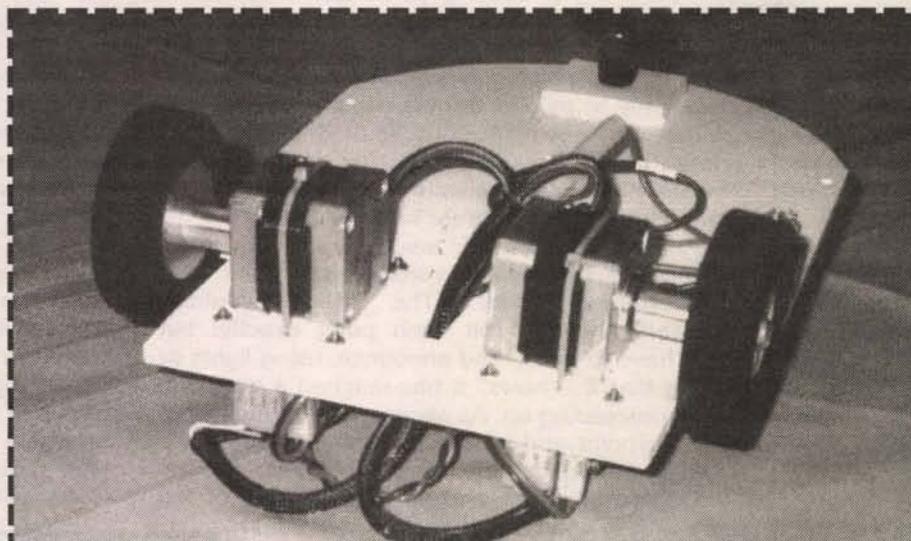
You can find many books and papers dealing with ramping algorithms, and some of the ramping strategies get quite complex. But try starting out with a simpler two-

three-speed ramp such as I described above; you'll likely find it clears up any problems you might have with stalling steppers on start-up.

I covered the details of issuing stepper pulses in the July '96 article, so I won't go over that ground again. I will, however, spend some time on the concept of a motion table for describing exactly how the robot moves about. Unlike previous robots such as Huey, which reacts to its environment, this machine blindly moves in a prescribed pattern. Each element of this pattern contains at least three pieces of information for the right and left motors. For each motor, you have to provide the delay between steps, the number of steps in the element, and the direction of motion. In SBASIC, you can use the DATA table in Figure 1 to house this information.

This table entry describes a motion element that causes the robot to spin clockwise about its center point for a total of 2200 steps on either motor. Each step in the motion requires 5000 time ticks on the 68hc11 which, at 8 MHz a default timer prescaler works out to 2.5 msec per step, or 400 steps per second.

The next two entries contain the number of steps to issue for each motor. Note that this motion



The underside of the DR robot, showing the two Vexta steppers that provide power. I fastened the motors in place using foam tape, then added a nylon wire tie to each for extra security. Note the direct drive mounting system; I used shaft adapters machined for me by the SRS' Dan Mauch.

required sturdier fasteners than just foam tape. So after I got everything taped down exactly where I wanted it, I marked and drilled holes into the Sintra base, then ran a single nylon wire tie around each major component. The adhesive on the foam tape keeps the large objects from shifting or rotating in place, and the wire tie keeps them from lifting off the tape, even if I pick up the robot by the battery or the motors.

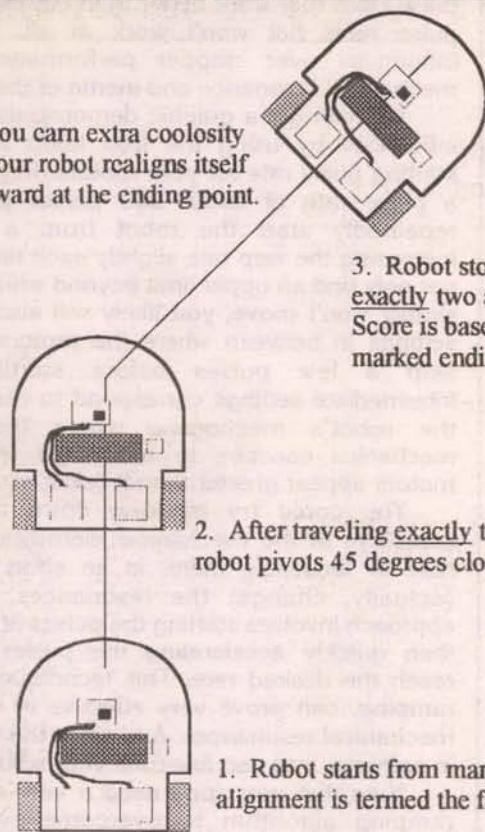
### The DR software

In theory, the dead-reckoning software seems quite simple. A couple of quick calculations give you the number of steps to make to cover a prescribed distance. For example, my robot uses 2-3/4" diameter wheels, which means a wheel measures  $2.75 \times 3.14159$  inches in circumference, or 8.64 inches. Given 39.36 inches per meter, this works out to 4.55 full revolutions. Since my robot uses half-stepping, it needs to issue 400 steps per revolution, or 1820 steps per meter. For two meters, this becomes 3640 steps.

But you cannot just fire off 3640 steps at any old rate and get consistent stepper performance. You will find that stepper systems have a range of

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NOTE: You earn extra coolosity points if your robot realigns itself facing forward at the ending point.



OVERVIEW OF THE DEAD-RECKONING EVENT

table contains no information regarding half- or full-stepping; the step type must be set elsewhere. The entry shown will move each motor exactly 2200 steps, but obviously a half-stepping robot will only travel half as far as a full-stepping robot. The last two entries contain previously defined constants that control the direction of motion.

Despite its simplicity, this table scheme can prove very flexible. For example, you can use it to incorporate ramping by including a couple of entries with only three or four steps each, but with decreasing step delays. I have written an SBasic library for stepper motors built around this table concept, and made it available on my Web site. Feel free to build on my original code, adding features you think necessary.

One change you might include would add the option of disabling the motors for a fixed delay. Disabling the motors removes the current from the coils, dramatically reducing current drain from your battery. Such a feature might be handy if your robot needed to execute several sequences with long delays between them.

You will need to alter my step count values, based on the diameter of the wheels you put on your robot. The math for calculating the basic move and turn functions is straightforward, though you

pair of marked points, perhaps about a meter apart, could serve as pylons. Robots could be required to navigate either an ellipse or a figure-8 around these pylons before heading for the ending point. Obviously, the coordinates of the two pylons would have to be announced prior to the event.

Another option would involve a tour of several different marked points, visiting each point in a predetermined order. The robot wouldn't necessarily have to hit each point exactly, but might have to pause and announce, using lights or beeper, that it "knows" it has reached a waypoint before proceeding on. As above, the coordinates of each waypoint and its order in the visit sequence would be announced prior to competition.

Or you could offer a variation geared for the more artistic robot builders. A robot would be placed at the starting point, then given up to two minutes to go anywhere on the arena, in whatever path it chooses, before returning to the starting point. A panel of judges would assign a numeric score to the artistic value and the difficulty of the "floor exercise" performed. The average of this score, added to an accuracy value based on how precisely the robot returned to the starting point, would determine the robot's

## FIGURE 1 — DATA 1

DATA 5000, 5000  
DATA 2200, 2200  
DATA STEP\_FWD, STEP\_REV

' left and right step delays  
' left and right step counts  
' left and right step direction

might want to throw in a little ramping to get your robot up to speed. Remember to allow for the steps used in ramping in your overall step count. I know it's only a few steps, but not taking them into account would certainly knock you out of an SRS competition.

### Adding wrinkles

After you have your DR robot running, you can think about changing the event slightly to add complexity and crowd appeal. The DR event basically requires a robot that can work in a Cartesian grid system, a feature you can exploit in highly cool wrinkles to the basic event.

For example, you could require that a robot leave the starting point and map out a more complex pattern before reaching the ending point. A

arena's surface, which would now be covered with a large sheet of paper. This essentially turns the robot into a movable plotter head, allowing your software to trace out complex designs. This event would place a premium on careful design and artistic creation, and should be a real crowd-pleaser.

Carried one step further (sorry about that), two or more robots could work together as a team, tracing out intricate patterns around each other on the arena floor. After a specified amount of time, each would have to find its way back to the proper ending point, with the judges scoring on both artistic merit and precision.

The dead-reckoning robot, with its premium on precision mechanics and software, opens up new possibilities and makes a great showcase for your skills. While I'm sure you enjoy building behavior-based robots as much as I do, take the time to build one of these stepper-motor machines. I think you'll like the new opportunities it presents.

### Wowser Web Site

Kevin Ross, president of the Seattle Robotics Society, has set up a first-rate Robot Builder's Page. This site, attached to his home page, is actually an extensive HTML article on building a small robot using a BOTBoard and one of Marvin Green's plastic, two-tiered bases. Links within this document describe vital subelements, such as how to modify an R/C servo so it goes round and round instead of just back and forth. Kevin also has included many beautiful, high-quality photos of his construction techniques. The photos in the servo modification section are super, and really add to the textual instructions.

Kevin's RoboGuide, as he calls it, is an expanding work and will doubtless mutate as his time and inclinations allow. Check in now and then on what I know will become a much-visited robotics site. You can reach Kevin's home page at: [www.nwlink.com/~kevinro](http://www.nwlink.com/~kevinro) NV

**As always, you can reach me at:**

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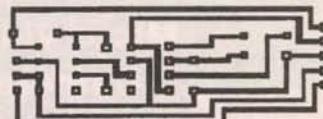
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Nuts & Volts Magazine/November 1996 99

## MISC. ELECTRONICS FOR SALE

PANASONIC TU-1000X Teletext NABTS decoder. NEW w/remote. Only \$29. 1-800-837-2851.

**HOME AUTOMATION** & computer control: Two-way IR, Two-way X-10, & hardwire. Control devices from serial computer link or stand-alone operation. Call for free catalog. CompCo, 423-436-5189.

BELDEN COAX RG59/0 75 ohms. 11 new 1,000 ft. rolls. \$39/roll. 3-wire 12AWG black extension cords, molded plugs, \$77 list. Sale \$25. Scott's Electronic Surplus 310-491-3181. Fax 310-491-3182.

### Synthesized FM Stereo Transmitter



Microprocessor controlled for easy freq programming using DIP switches, no drift, your signal is rock solid all the time - just like the commercial stations. Audio quality is excellent, connect to the line output of any CD player, tape deck or mike mixer and you're on-the-air. Foreign buyers will appreciate the high power output capability of the FM-25; many Caribbean folks use a single FM-25 to cover the whole island! New, improved, clean and hum-free runs on either 12 VDC or 120 VAC. Kit comes complete with case set, whip antenna, 120 VAC power adapter - easy one evening assembly.

FM-25, Synthesized FM Stereo Transmitter Kit ..... \$129.95



### Tunable FM Stereo Transmitter

A lower cost alternative to our high performance transmitters. Offers great value, tunable over the 88-108 MHz FM broadcast band, plenty of power and our manual goes into great detail outlining aspects of antennas, transmitting range and the FCC rules and regulations. Connects to any cassette deck, CD player or mixer and you're on-the-air, you'll be amazed at the exceptional audio quality! Runs on internal 9V battery or external power from 5 to 15 VDC, or optional 120 VAC adapter. Add our matching case and whip antenna set for a nice finished look.

FM-10A, Tunable FM Stereo Transmitter Kit ..... \$34.95  
CFM, Matching Case and Antenna Set ..... \$14.95

### RF Power Booster Amplifier



Add some serious muscle to your signal, boost power up to 1 watt over a frequency range of 100 KHz to over 1000 MHz! Use as a lab amp for signal generators, plus many foreign users employ the LPA-1 to boost the power of their FM Stereo transmitters, providing radio service through an entire town. Power required: 12 to 15 volts DC at 250mA, gain of 38dB at 10 MHz, 10 dB at 1000 MHz. For a neat, professionally finished look, add the optional matching case set.

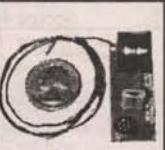
LPA-1, Power Booster Amplifier Kit ..... \$39.95  
CLPA, Matching Case Set for LPA-1 Kit ..... \$14.95  
LPA-1WT, Fully Wired LPA-1 with Case ..... \$99.95

### Micro FM Wireless Mike

World's smallest FM transmitter. Size of a sugar cube! Uses SMT (Surface Mount Technology) devices and mini electret condenser microphone, even the battery is included. We give you two complete sets of SMT parts to allow for any errors or mishaps-build it carefully and you've got extra SMT parts to build another! Audio quality and pick-up is unbelievable, transmission range up to 300 feet, tunable to anywhere in standard FM band 88 to 108 MHz. 7/8" w x 3/8" h x 3/4" h.

FM-5 Micro FM Wireless Mike Kit ..... \$19.95

### Crystal Controlled Wireless Mike



Super stable, drift free, not affected by temperature, metal or your body! Frequency is set by a crystal in the 2 meter Ham band of 146.535 MHz, easily picked up on any scanner radio or 2 meter rig. Changing the crystal to put frequency anywhere in the 140 to 160 MHz range-crystals cost only five or six dollars. Sensitive electret condenser mike picks up whispers anywhere in a room and transmit up to 1/4 mile. Powered by 3 volt Lithium or pair of watch batteries which are included. Uses the latest in SMT surface mount parts and we even include a few extras in case you sneeze and loose a part!

FM-6, Crystal Controlled FM Wireless Mike Kit ..... \$39.95  
FM-6WT Fully Wired FM-6 ..... \$69.95

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PANASONIC TU-1000X Teletext NABTS decoder. NEW w/remote. Only \$29. 1-800-837-2851.

**PROTOTYPES OR** large runs. PCBs, wave soldering, cabinets and other metal parts, silk screen printing, plastic injection, xformer/coil winding, etc. Assembly, wiring. Very low prices! Twin plant in Mexico. We ship to your door. V&V. Ph. 713-537-7518 Fax 011-525-361-5996.

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**SPECIAL SALE:** Handheld DMM, 3.5 digit, 0.5" LCD, w/transistor/diode tester sckt. = \$22.95 ea. PC board carbide drills=\$0.30 ea. Switching power supply: In:120/240 VAC Out: 9VDC @ 5.6A=\$14.95 ea. Gold plated dual 5-way binding post=\$2.25 ea. Gold plated RCA phono jack, chassis mt.=\$1 ea. (2 for \$1.65). Adjustable pos. or neg. voltage reg. IC output from 1.2 to 32VDC @ 3 amps. TO-3 case=\$1.75 ea. (5+ \$1.25 ea.). Contactor: Coil: 120V 50/60 Hz. Contacts: 30A @ 120VAC res. SPST N/O=\$5.95 ea. Power transistors: Motorola #MJ15024 NPN or #MJ15025 PNP, 250V/250 watt, TO-3 case=\$1.75 ea. (10+ \$1.25 ea.). Toshiba #2SC3281 NPN 200V/150 watt, TO-3PBL case=\$1.50 ea. (10+ \$1.25 ea.). Motorola #MTP50N05E power MOS-FET 50 amp/50V. TO-220AB case=\$1.55 ea. (10+ \$1.15 ea.). Some supplies limited. We carry many other electronic parts. Call/fax/send for free flyer. We ship UPS ground. Large qty. discounts. Hoffman Industries, 853 Dundee Ave., Elgin, IL 60120. Ph: 847-622-8201, Fax 847-622-8202.

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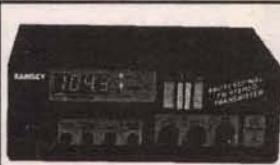


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**SOLAR KING'S** many millions of dollars of solar panels in stock. Solar panels: Credit card solar panel. Credit card size & plastic 8VCD .03 amp panel, may be combined for many voltages & current applications, \$5, \$25/5: 12"x12" 15V, 3W, .25A, \$19.95, \$170/10, \$800/50, \$1,550/100. 12"x6" 15V @ 1.25A, 1.5W, \$19.95, \$140/10, \$1,200/100, \$9,000/1,000, 6"x6" 7.2V @ .065A, .75W, \$6.95, \$59/10, \$500/100, \$3,990/1,000. Wholesale, retail, mail order. Material running low. New solar material coming in all the time. Many other solar items available. Cat'l SASE. BNFE, Rte. 1S, Peabody, MA 01960, WWW.BNFE.COM V508-536-2000, F508-536-7400. Estab. 1964.

**ELECTRONIC ASSEMBLY MACHINERY.** We buy and sell assembly machinery including solder machines and board cleaners, insertion machines and lead formers. Petlock Inc., Rialto, CA. 909-877-8900, FAX 909-877-8902.

### RAMSEY Super Pro FM Stereo Radio Transmitter



we've packed into the FM-100. Set frequency easily with the Up/Down freq buttons and the big LED digital display. Plus there's input low pass filtering that gives great sound no matter what the source (no more squeals or swishing sounds from cheap CD player inputs!) Peak limiters for maximum 'punch' in your audio - without over modulation, LED bargraph meters for easy setting of audio levels and a built-in mixer with mike and line level inputs. Churches, drive-ins, schools and colleges find the FM-100 to be the answer to their transmitting needs, you will too. No one offers all these features at this price! Kit includes sharp looking metal cabinet, whip antenna and 120 volt AC adapter. Also runs on 12 volts DC.

We also offer a high power export version of the FM-100 that's fully assembled with one watt of RF power, for miles of program coverage. The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported.

FM-100, Professional FM Stereo Transmitter Kit ..... \$299.95  
FM-100WT, Fully Wired High Power FM-100 ..... \$429.95

### Speech Descrambler Scrambler



Decode all that gibberish! This is the popular descrambler / scrambler that you've read about in all the Scanner and Electronic magazines. The technology used is known as speech inversion which is compatible with most cordless phones and many police department systems, hook it up to scanner speaker terminals and you're in business. Easily configured for any use: mike, line level and speaker output/inputs are provided. Also communicate in total privacy over telephone or radio, full duplex operation - scramble and unscramble at the same time. Easy to build, all complex circuitry contained in new custom ASIC chip for clear, clean audio. Runs on 9 to 15VDC, RCA phone type jacks. Our matching case set adds a super nice professional look to your kit.

SS-70A, Speech Descrambler/Scrambler Kit ..... \$39.95  
CSS, Custom Matching Case and Knob Set ..... \$14.95  
SS-70AWT, Fully Wired SS-70A with Case ..... \$79.95  
AC12-5, 12 Volt DC Wall Plug Adapter ..... \$9.95

### Tone-Grabber Touch Tone Decoder / Reader



Dialed phone numbers, repeater codes, control codes, anywhere touch tones are used, your TG-1 will decode and store any number it hears. A simple hook-up to any radio speaker or phone line is all that is required, and since the TG-1 uses a central office quality decoder and microprocessor, it will decode digits at virtually any speed! A 256 digit non-volatile memory stores numbers for 100 years - even with the power turned off, and an 8 digit LED display allows you to scroll through anywhere in memory. To make it easy to pick out numbers and codes, a dash is inserted between any group or set of numbers that were decoded more than 2 seconds apart. The TG-1 runs from any 7 to 15 volt DC power source and is both voltage regulated and crystal controlled for the ultimate in stability. For stand-alone use add our matching case set for a clean, professionally finished project. We have a TG-1 connected up here at the Ramsey factory on the FM radio. It's fun to see the phone numbers that are dialed on the morning radio show!

Although the TG-1 requires less than an evening to assemble (and is fun to build, too), we offer the TG-1 fully wired and tested in matching case for a special price.

TG-1, Tone Grabber Kit ..... \$99.95

CTG, Matching Case Set for TG-1 Kit ..... \$14.95

TG-1WT, Fully Wired Tone Grabber with Case ..... \$149.95

AC12-5, 12 Volt DC Wall Plug Adapter ..... \$9.95

### Mini-Peeper Micro Video Camera



Super small, high quality fully assembled B & W CCD TV camera the size of an ice cube! Provides excellent pictures in low light (2 lux), or use our IR-1 Infra-Red light source to visibly illuminate an entire room on a pitch black night! Imagine the possibilities... build it into a smoke detector, wall clock, lamp, book, radio. Exact same camera that's in big buck detective catalogues and stores. Kit includes: fully assembled CCD camera module, connectors, interface PC board kit with proper voltage regulation and filtering, hook-up details, even a mini microphone for sensitive sound! Two models available: Wide Angle Lens 3.6mm/f2, adjustable focus lens, 92 degree view; Pinhole Lens 5.5mm/f4.5, 60 degree view. The Pinhole Lens is physically much flatter and provides even greater depth of focus. The camera itself is 1.2" square. The Wide Angle Lens is about 1" long, Pinhole Lens about 1/2", interface PC board is 1" x 2" and uses RCA jacks for easy hook-up to VCRs, TVs or cable runs. Power required is 9 to 14 VDC @ 150 mA. Resolution: 380 x 350 lines. Instruction manual contains ideas on mounting and disguising the Mini-Peeper along with info on adding one of our TV Transmitter kits (such as the MTV-7 unit below) for wireless transmission!

MP-1, Wide Angle Lens CCD TV Camera Outfit ..... \$169.95

MP-1PH, Pin-Hole Lens CCD TV Camera Outfit ..... \$189.95

### MicroStation Synthesized UHF TV Transmitter



Now you can be in the same league as James Bond. This transmitter is so small that it can fit into a pack of cigarettes - even including a CCD TV camera and battery! Model airplane enthusiasts put the MTV-7A into airplanes for a dynamite view from the cockpit, and the MTV-7A is the transmitter of choice for balloon launches. Transmitter features synthesized, crystal controlled operation for drift-free transmission of both audio and video on your choice of frequencies: Standard UHF TV Channel 52 (which should only be used outside of the USA to avoid violating FCC rules), and 439.25 MHz or 911.25 MHz which are in the amateur ham bands. The 439.25 MHz unit has the nifty advantage of being able to be received on a regular "cable-ready" TV set tuned to Cable channel 68, or use our AT-74 converter and receive it on regular TV channel 3. The 911.25 MHz unit is suited for applications where reception on a regular TV is not desired, an AT-79 must be used for operation. The MTV-7A's output power is almost 100 mW, so transmitting range is pretty much "line-of-sight" which can mean many miles! The MTV-7A accepts standard black and white or color video and has its own, on-board, sensitive electret microphone. The MTV-7A is available in kit form or fully wired and tested. Since the latest in SMT (Surface Mount Technology) is used to provide for the smallest possible size, the kit version is recommended for experienced builders only. Runs on 12 VDC @ 150 mA and includes a regulated power source for a CCD camera.

MTV-7A, UHF TV Channel 52 Transmitter Kit ..... \$159.95

MTV-7AWT, Fully Wired Channel 52 Transmitter ..... \$249.95

MTV-7A4, 439.25 MHz TV Transmitter Kit ..... \$159.95

MTV-7A4WT, Fully Wired 439.25 MHz Transmitter ..... \$249.95

MTV-7A9, 911.25 MHz TV Transmitter Kit ..... \$179.95

MTV-7A9WT, Fully Wired 911.25 MHz Transmitter ..... \$269.95

ATV-74, 439.25 MHz Converter Kit ..... \$159.95

ATV-74WT, Fully Wired 439.25 MHz Converter ..... \$249.95

ATV-79, 911.25 MHz Converter Kit ..... \$179.95

ATV-79WT, Fully Wired 911.25 MHz Converter ..... \$269.95

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**RG-384 COAXIAL** cable, 500' \$100 delivered. 2000' \$100 FOB Jacksonville. Sample \$3. Send check to: William Miller, Box 201, Jacksonville, IN 47438.

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**NIM BINS,** back-plains, amplifiers, high voltage power supplies, filters, counters, others. By Ortec and Eletrox. For complete list, Fax request to 409-258-4421.

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**GREAT PARTS** and prices. Send \$3 for our 96-page catalog. Hardware, caps, surface mount parts. We pay shipping. Visa & MC. Phone/FAX 702-795-7151. Star-Tronics, Box 98102, Las Vegas, NV 89193.

**ATTN: TELECOM** transmission engineers. For sale: HP AC voltmeter model 403B 1mw, 600 ohm. \$100 OBO. 714-494-0072.



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**18" FLOW** solder machine, Hollis Mark II, computerized, finger-type. Auto fluxer & recorder. Halon fire ext. system. Asking \$6,500. So Cal 619-736-4411.

**CAN I** get information on a Honeywell WCU 485 vertical gyroscope circa 1970? It operates on 400Hz power supply. Joseph Rayzak, 77 Combes Ave., Hicksville, NY 11801.

**200 WATT DC** to AC inverter. Great for RVs. NEW. \$69. 1-800-837-2851.

**Try a classified ad in Nuts & Volts. They're inexpensive and they work! Details on page 120.**

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**MICROWAVE MIKE**, the RF Plumber, needs waveguide, fixed and transportable microwave radios, and related hardware. Fax your available inventory to 609-875-7577 or Call 609-875-1189.

**DEC EQUIPMENT WANTED!!!** We are buying DEC systems, boards, terminals, drives and peripherals. Also Scientific Micro Systems (SMS), DSD, Database, Dilog, other DEC compatibles, and Computer Output Microfilm (COM) units. Please call for a quote or fax us your equipment list. We buy, sell, and trade. **KEYWAYS, INC.**, 513-847-2300 OR fax 513-847-2350.

**WANTED: TUBE HiFi, Tube theater/commercial amps, speakers etc. Corner speakers/coaxials/triaxials. Old guitars & guitar amps. Altec, McIntosh, Marantz, Western Electric, Scott, Fisher, Dynaco, Electrovoice, Jensen, Gibson, Fender, Vox etc. Sonny Goldson, 1413 Magnolia Ln., Midwest City, OK 73110. 405-737-3312. FAX 405-737-3355.**

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**WANTED: MILITARY "MILES" systems.** Parts, transmitters, receivers, helmet and chest sensors, test sets, manuals, etc. BPB Assoc., 1977 High St., Longwood, FL 32750. 407-330-3408, FAX 407-330-3498.

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A great item for tube amps, high voltage power supplies, etc., this mega capacitor measures 4.5" x 2-3/4" dia, with 2 screw terminal contacts and a base lug for mounting or stabilizing.



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- 1] copy circuit pattern on TEC-200 film using any plain paper copier
- 2] iron film on to copper clad board
- 3] peel off film and etch

5 sheets, 8-1/2" x 11" \$4.95  
instructions included



### TELEPHONE KIT \$19.95

'That's right, it says TELEPHONE KIT! You can build your own clear telephone with flashing neon lights and redial system just under twenty bucks!! The clear plastic case allows you to show off your circuit wizardry, and the kit provides you with a working phone that features last number automatic redial, flashing neon lights when ringing, and a mute button (if only they could put one of those on Aunt Joan!) Kit comes complete with all parts (9 volt battery not included), and is surprisingly easy to build! Phone hangs up on any flat surface (or hang it on the wall, it comes with a wall cradle!), looks professional with convenient touch button key pad, and a great set of instructions covering basic theory of operation, how to put the kit together, and appropriate schematic diagrams.



### VIRTUAL REALITY COLOR VIDEO HEADSET WITH AUDIO AND MOTION SENSOR \$65.00

**Watch late night TV without disturbing anyone!** This video viewing system can be connected to your VCR and you can watch (and hear) your program on the headset! Of course, it is not like the picture on that 12 foot big screen at the local sports pub, but you can watch in your jammies and see who the guests are on your favorite late night talk show!

**Play your favorite video games arcade style!**

Designed for use with many Super NES and Sega Genesis games, the headset has both audio and motion sensing capabilities. Generally speaking, this is ideal for racing, flight, and tank simulators with a first person or rear view perspective, and games with an eye level perspective. System features volume control, sensitivity control, brightness control, tint control, as well as a reset button and mode switches to select your application.

Composite video headset system includes headset, tracking tube (for motion sensing), AC adapter, Super NES cable assembly and Sega Genesis cable assembly. A pinout is also included for TV/VCR viewing.

**127 THERMOCOUPLES** The peltier junction is a solid-state thermovoltaic device. Current applied to the device will produce heat on one side of the device and a cold surface on the other side. Water placed on the surface will freeze or boil depending on polarity of applied voltage. Ideal for applications from 3-12 VDC - grab a battery and let your imagination run wild!

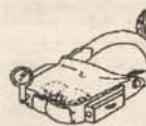
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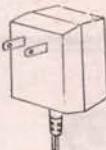
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Pentium 166MHz Intel.....\$539 200MHz Intel.....\$789 All w/Built-in EIDE  
Pentium PRO 150MHz Intel.....\$879 Pentium PRO 200MHz Intel.....\$1099  
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Add \$15 for Intel VXi chipset.

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8MB 2x32 (72pin) 60ns.....\$45 \$49 16MB.....\$179  
16MB 4x32 (72pin) 60ns.....\$119 \$129  
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SD RAM

14.4 Fax/Voice.....\$39  
28.8 Fax/Voice.....\$60

10.4ms (E-IDE).....\$175  
10.4ms (E-IDE).....\$199  
9ms (E-IDE).....\$219  
9ms (E-IDE).....\$269  
9ms (E-IDE).....\$319

1.2Gig Maxtor.....\$175  
1.6Gig Maxtor.....\$199  
2.0Gig Maxtor.....\$219  
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Modems

14.4 Fax/Voice.....\$39  
28.8 Fax/Voice.....\$60

1.4ms (E-IDE).....\$175  
1.4ms (E-IDE).....\$199  
1.4ms (E-IDE).....\$219  
1.4ms (E-IDE).....\$269  
1.4ms (E-IDE).....\$319

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28.8 Fax/Voice.....\$60

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1.4ms (E-IDE).....\$199  
1.4ms (E-IDE).....\$219  
1.4ms (E-IDE).....\$269  
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Handheld,  
battery operated.  
Produces an intense  
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LAGUN2 Plans ..... \$20.00  
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**250KV Tesla Coil**

10-14" of Explosive  
Bolts of Lightning!  
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#### Visible Beam Gas Lasers

Millions degree temp equiv. Illuminates low

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• Light Shows  
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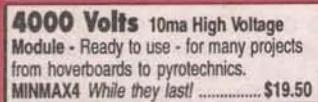
LAS1KM 1 mw, low cost Kit ..... \$69.50

LGU6K 2-3mw Kit ..... \$119.50

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**Ion Ray Gun**  
Project Energy!  
Star Wars technology demonstrates  
weapons potential. IOG7K Kit/Plans \$99.50



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Module - Ready to use - for many projects  
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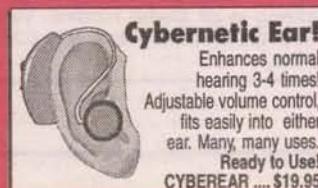
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prototype designed  
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• Ballistic Velocities  
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- to your spec's!

Call or fax us with your requirements!

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Enhances normal  
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Adjustable volume control,  
fits easily into either  
ear. Many, many uses.  
Ready to Use!  
CYBEREAR .... \$19.95



**Telephone Line Grabber/  
Infinity Transmitter**

Use tone phone anywhere in the world to:  
• Monitor your premises - avoid break-ins  
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**Long Range "Ultra-Ear"**

20" dish uses satellite  
technology to capture  
distant sounds. PMS Plans ..... \$8.00  
PM5K Kit/Plans ..... \$149.50



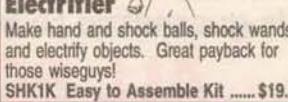
**Phasor Sonic Blast Pistol**

Rids areas of unwanted pests.  
Trains and conditions wild and  
domestic animals. Great for  
barns, attics, cellars, gardens.  
PPP1K Kit/Plans ..... \$39.50



**Shocker Force Field/  
Vehicle Electrifier**

Make hand and shock balls, shock wands  
and electrify objects. Great payback for  
those wiseguys!  
SHK1K Easy to Assemble Kit ..... \$19.50

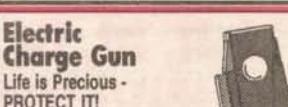


Shoots flaming ball - two shot

capacity. Great for special effects and

remote fire starting. CAUTION REQUIRED!

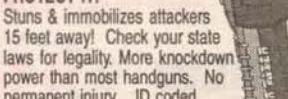
FIREBALL Plans (dangerous product) ..... \$10.00



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DARKNESS!**

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Scope with IR illuminator.

SD10 Ready to Use ..... \$199.50



**Electric Charge Gun**

Life is Precious -  
PROTECT IT!

Stuns & immobilizes attackers  
15 feet away! Check your state  
laws for legality. More knockdown  
power than most handguns. No  
permanent injury. ID coded.  
ECG1 Data

(Creditable to purch.) ..... \$10.00

ECG10 Charge Gun, Ready to Use,

includes FREE Stun Gun! ..... \$249.50

STUN GUNS - sold separately:

STUN100 100,000 Volts ..... \$34.50

STUN200 200,000 Volts ..... \$49.50



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Not a Toy! Uses electronic or piezo-

ignition. CAUTION REQUIRED!

POT1 Plans (dangerous product) ... \$10.00



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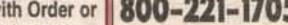
STUN GUNS - sold separately:

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## Events CALENDAR

Continued from page 29

**TX - SAN ANTONIO** - Hamfest. San Antonio RC. Eric Smith 210-684-2513

**VA - ANNANDALE** - Computer Show. N. Virginia Community College. MarketPro 301-984-0880 xt15

**JANUARY 11-12**

**FL - JACKSONVILLE** - Computer Show Jacksonville Fairgrounds. MarketPro 301-984-0880 xt15

**FL - SARASOTA** - Hamfest. Sarasota ARA. Fred Auernbach 941-365-7679

**KY - LOUISVILLE** - Computer Show. Commonwealth Convention Ctr. MarketPro 301-984-0880 xt15

**OH - BEREA** - Computer Show. Cuyahoga County Fairgrounds. MarketPro 301-984-0880 xt15

**PA - ALLENTOWN** - Computer Show. Allentown Fairgrounds. MarketPro 301-984-0880 xt15

**JANUARY 12**

**MD - NEW CARROLLTON** - Computer Show. Ramada Conf. & Exhibition Ctr. MarketPro 301-984-0880 xt15

**WI - WAUKESHA** - Hamfest. West Allis RAC. Phil Gural 414-425-3649

**JANUARY 13**

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

**FL - CRYSTAL RIVER** - Hamfest. Sky High ARC. 352-746-1299

**MD - FREDERICK** - Computer Show. Frederick Fairgrounds. MarketPro 301-984-0880 xt15

**MI - FLINT** - Hamfest. Southwestern Academy. Keith Allen N8QNA 810-232-5170

**MO - ST. JOSEPH** - Hamfest. Ramada Inn. Missouri Valley ARC. 816-424-6484

**NH - NASHUA** - Electronic Fleamart. 617-923-2665

**NH - SALEM** - Computer Show. Rockingham Park Race Track. Northern Computer 508-744-8440

**VA - RICHMOND** - Computer Show. The Showplace. MarketPro 301-984-0880 xt15

**JANUARY 18-19**

**FL - MIAMI** - Computer Show. Coconut Grove Conv. Center. MarketPro 301-984-0880 xt15

**OH - DAYTON** - Computer Fair. Dayton Convention Center. Trade Show Productions 513-263-3378

**OH - DAYTON** - Computer Show. Montgomery County Fairgrounds. MarketPro 301-984-0880 xt15

**JANUARY 19**

**IL - GLEN ELLYN** - Computer Show & Sale. College of DuPage. Computer Central Shows 708-940-7547

**MA - SWANSEA** - Computer Show. Venus DeMilo. Northern Computer Shows 508-744-8440

**NY - YONKERS** - Electronic Flea Market. Lincoln High School. Otto 914-969-1053

**OH - BROADWAY** - Winter Ham Radio Fair. 937-246-5943

**VA - NORFOLK** - Computer Show. Norfolk Scope. MarketPro 301-984-0880 xt15

**VA - RICHMOND** - Hamfest. Amateur Telecommunications Society. Craig Spain 804-526-9838

**JANUARY 20**

**OH - NILES** - Computer Show. Eastwood Expo Center. MarketPro 301-984-0880 xt15

**JANUARY 25**

**IN - FT. WAYNE** - Computer Show. Allen County Fairgrounds. MarketPro 301-984-0880 xt15

**IN - INDIANAPOLIS** - AGI Computer Fair. Indianapolis Events Center. 317-299-8827

**MA - STURBRIDGE** - Computer Show. Sturbridge Host Hotel. Northern Computer Shows 508-744-8440

**JANUARY 25-26**

**MD - GAITHERSBURG** - Computer Show. Montgomery Co. Fairgrounds. MarketPro 301-984-0880 xt15

**OH - CINCINNATI** - Computer Show. Cincinnati Gardens. MarketPro 301-984-0880 xt15

**JANUARY 26**

**CA - SANTA ANA** - Swapmeet. ACP Parking Lot. Mary Russo 714-558-8813

**IN - SOUTH BEND** - Computer Show. Century Center. MarketPro 301-984-0880 xt15

**MD - ODEONTON** - Hamfest. Maryland Mobileers ARC. Jim Bottlik 410-280-9815

**MI - MIDLAND** - Computer Show. Holiday Inn. Five Star Productions. 810-230-0988

**NH - NASHUA** - Computer Show. Sheraton Tara Hotel. Northern Computer Shows 508-744-8440

**OH - DOVER** - Hamfest. Ohio National Guard Armory. Howard Blind 330-364-5258

**PA - WILKES BARRE** - Computer Show. Genetti's Best Western. MarketPro 301-984-0880 xt15

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Paw Paw 49079  
**Purchase Radio Supply, Inc.**  
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Ann Arbor 48104  
**Tower Records**  
1214 S. University Ave.  
Ann Arbor 48104  
**MINNESOTA**  
**Radio City, Inc.**  
2633 County Road 1  
Mounds View 55112  
**MISSOURI**  
**Accurate Instruments**  
11201 E. 24 Highway  
Independence 64054  
**Electronics Exchange**  
8644 St. Charles Rock Road  
St. Louis 63114

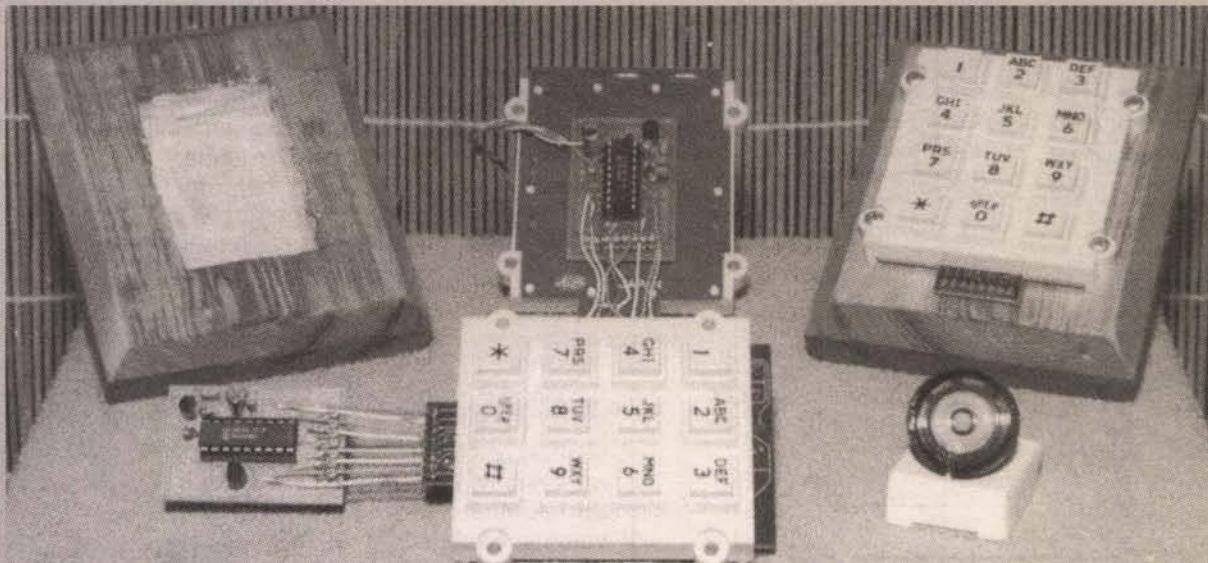
#### **Stewart & Associates**

204 Sonderen St.  
O'Fallon 63366  
**NEBRASKA**  
**Ladd Electronics Co.**  
111 N. 41st St.  
Omaha 68131  
**NEVADA**  
**Amateur Electronic Supply**  
1072 N. Rancho Drive  
Las Vegas 89106  
**Less Buster's Electronics**  
2930 N. Las Vegas Blvd.  
VSTG-22  
North Las Vegas 89030  
**Radio World**  
1656 Nevada Hwy  
Boulder City 89005  
**Tower Records/Video**  
4580 W. Sahara Ave.  
Las Vegas 89102  
6450 South Virginia  
Reno 89511  
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**JR Tech Systems**  
1309 Highway 71  
Belmar 07719  
**Tower Records**  
809 Route 17 South  
Paramus 07652  
**NEW YORK**  
**All Phase Video Security, Inc.**  
70 Cain Drive  
Brentwood 11717  
**Ham Central**  
3 Neptune Road  
Poughkeepsie 12601  
**Hirsch Sales Corporation**  
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Williamsville 14221  
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105 Old Country Road  
Carte Place 11514  
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Huntington 11746  
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Mentor 44060  
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Toledo 43613  
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2700 Sunset Blvd.  
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**Keyways, Inc.**  
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Miamisburg 45342  
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Toledo 43604  
**Powermaxx, Inc.**  
1587 U.S. Route 68 North  
Xenia 45385  
**The Multimedia Exchange**  
7984 Columbia Rd.  
Olmsted Falls 44138  
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**News & Smokes**  
2295 W. Main St.  
Medford 97501  
**News & Smokes #8**  
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**Norvac Electronics**  
7940 SW Nimbus Ave. Bldg. 8  
Beaverton 97005  
960 Conger  
Eugene 97402  
1545 N. Commercial NE  
Salem 97303  
**Powell's Technical Bookstore**  
33 NW Park  
Portland 97209

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Red Lion 17356  
**Penn Electronics**  
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Harrisburg 17103  
**Tower Books**  
425 South St.  
Philadelphia 19147  
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King of Prussia 19406  
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**555 Electronics**  
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Columbia 29203  
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**Electronic Equipment Bank**  
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Vienna 22180  
**Riley's Distributing**  
1045 Edom Road  
Harrisonburg 22801  
**Satellite Headquarters**  
7920 Timberlake Road  
Lynchburg 24502  
**Tower Records/Video/Books**  
4110 W. Ox Road #12124  
Fairfax 22033  
1601 Willow Lawn Drive  
Richmond 23230  
**VA Ham Radio Supply, Inc.**  
2208 Childress Rd.  
Christiansburg 24073  
**WASHINGTON**  
**A-B-C Communications, Inc.**  
17541 15th Avenue NE  
Seattle 98155  
**Amateur Radio Supply Co.**  
5963 Corson Ave. S. #140  
Seattle 98108  
**Martin Distributing**  
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Blaine 98231  
**Supertronix**  
18650 68th Avenue South  
Kent 98032  
**Tower Books**  
10635 NE 8th St.  
Bellevue 98004  
20 Mercer St.  
Seattle 98109  
2501 S. 38th St.  
Tacoma 98409  
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**Amateur Electronic Supply, Inc.**  
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Milwaukee 53223  
**Little Professor Book Center**  
307 N. Bridge St.  
Chippewa Falls 54729  
**News & Hobby Center**  
4758 Packard Ave.  
Cudahy 53110

# Fabricate this 12-KEY SERIAL KEYPAD Utilizing the U-54/56



by Michael Davenport

**E**cheapo redundancy. Here is what we all really need, nerds — an economical serial keypad to use in our projects. It would be lovely to have an enter key, escape, function, and miscellaneous keys, etc., and someone to come out and hook it up for us, but for only \$20.00 — use 12 keys.

Since you are the one programming your Stamp, PIC, or SBC, you can make 12 keys do a lot.

"\*" and "#" could be used

**FIGURE 1**

as function keys for "Enter," "Escape," etc.

## Serial Output

It comes puttin' out 1200 baud, no parity eight data bits, one stop blitz, all in inverted polarity, just like your PC eats for breakfast, if you so mode.

This project is built on the U-54/56 Carrier Board which was featured in the Oct. '96 issue of *Nuts & Volts*. If you ground point A0 on the U-54, the unit will operate at 2400 baud and if you ground point A1 on the U-54 the polarity

including start and stop bits will become "true polarity," a thing which is not false.

As is, the PIC outputs the ASCII values shown in Figure 1. This means that if you hook the keypad up to your PC's serial port and begin typing, each of the 12 keys will display on the screen exactly what is printed on the face of that key. If you want some custom value output by a particular key, tell me and I will personally program them into your PIC especially for you, individually. For example, instead of having the asterisk and pound keys output their ASCII equivalent values, you could

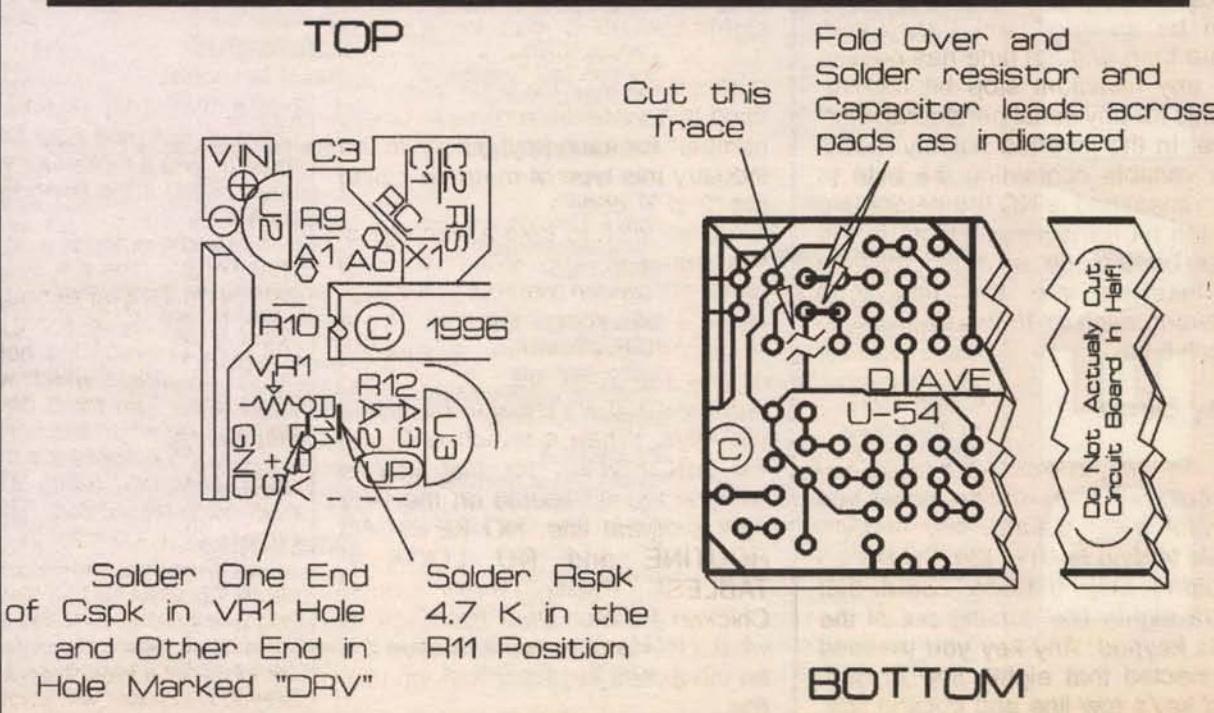
make the asterisk escape (#27d) and the pound sign could be enter (or "CR" which = #13d). When you order the PIC or kit, be sure and specify "Make key '\*' output decimal 27" — or whatever. I will rewrite all 12 keys if you like. As another example, each number key could generate that actual binary number instead of its ASCII equivalent, i.e., key "1" could = #00000001b instead of the way it ships, key "1" = #00110001b (or #49d).

Serial output is accomplished by rotating the bits off of the low end of the variable containing the byte to be transmitted and moving them

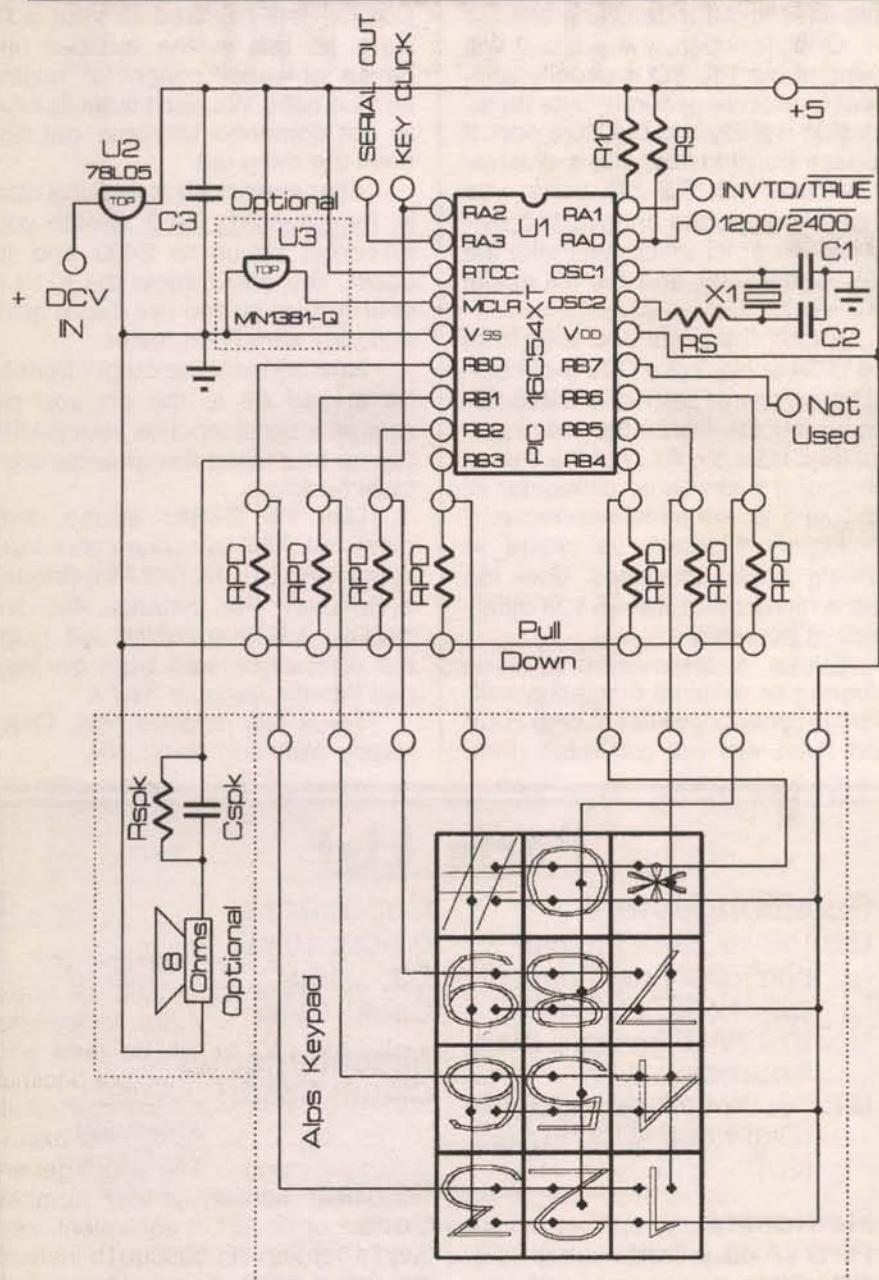
**Decimal Value Returned by Key**

Key "1"	# 49
Key "2"	# 50
Key "3"	# 51
Key "4"	# 52
Key "5"	# 53
Key "6"	# 54
Key "7"	# 55
Key "8"	# 56
Key "9"	# 57
Key "0"	# 48
Key "***"	# 42
Key "#"	# 35

**FIGURE 3 – KEYCLICK COMPONENTS**



**FIGURE 2 – K-12 SCHEMATIC**



into RA.3 one at a time in a loop with a decrementing control variable. The start and stop bits are XORed into the port to facilitate a simple method of switching between inverted and true polarity. There is no timing for the stop bit because by the time another key can be sampled and transmitted, more than enough time has passed for any minimum stop bit requirements for any serial peripheral interface. In the inverted polarity mode, the variable containing the byte to be transmitted is NOTed before use by the bit transmission loop. In the 1200 baud mode, an additional loop is inserted into the first loop between each bit to "waste twice as much time."

### Key Scan

As I began writing a typical "row by column" scan routine where you control each column line in turn, while testing each of the row lines, I couldn't help thinking about that extra eighth line coming out of the Alps keypad. Any key you pressed connected that eighth line to both that key's row line and column line.

You can see a representation of this in the keypad portion of Figure 2, the schematic diagram. The matrix is easier to visualize if you hold your magazine upside down while you view the schematic, giving the appearance of reading a *Mad Magazine*. If we put juice on that eighth line, when you press a button the +5V shows up on two different matrix lines at once — by gosh, the thing is generating a "unique binary number" for each key! (Okay, in the industry this type of matrix is called the "2 of 7" code.)

If we wish to take advantage of this situation and since we only have 12 unique numbers, we can make a simple comparison of the representative value appearing across the scan lines to 12 fixed numbers that we know to represent the keys. When a match is found, the ASCII value for that key is assigned to a variable on the very next program line. NO KEYS SCAN ROUTINE and NO LOOK-UP TABLES! Pretty funny huh? Chicken Farmer Doo-Doo Logic is what it is. Hard, but sure. Maybe it is an integrated keyscan/look-up routine.

One of the coolest things about a PIC is that there are so many different ways of doing, perfectly, any one thing. Who you are can have a lot to do with how you approach a problem and the logic of your solution. I enjoy going back and rewriting a routine to accomplish exactly the same thing, but use less lines and see how different the code can be made to look. This is a good exercise.

Would you like a challenging PIC exercise? Obtain the keypad and carrier board kit only, wire up the circuit described here, then write your own keyscan and serial I/O. Try coding a "2 of 7" routine, then try a version ignoring the common plane and put a +5V on each of the column lines, in turn, while checking the four row lines for the +5V.

In the key acquisition routine, the entire value of port RB is tested over and over again in a loop to see if it is zero and no other comparing is done. Only after port RB is not zero is the value at port RB stored and compared against the 12 fixed values. Each comparison is made at a cost of five program cycles, so in the worst case (if we have to make all 12 comparisons), there are 60 program cycles, which is equivalent to a total execution time for the whole block of only 3.1 ms. Dat fast enough.

Since we are reading the scan lines as a binary number and all of the pins on port RB have been designated as inputs, we need to pull down the pins on port RB to prevent any erroneous + pluses + from + "coming out of nowhere" +.

Here is a good example of how much room you actually have to work with in this smallest member of the PIC family. The last address used in this PIC application is #0A7h, or 167 instructions out of 512 available. We have used less than one third of the space available in our PIC! Isn't that wonderful? You can begin to imagine how much you

can do with one little 54.

### Key Click

We have borrowed the key click from a "Tick-Tock" circuit that is good for electronic art projects like clocks, a report at the end of an electromagnetically repulsed pendulum, etc. Tick-Tock really works best at 12 VDC, but it will make a sound with Cspk and Rspk at 10-220 uFd and 220 ohms-4.7 K respectively, here in the five-volt neighborhood, using any garden variety eight-ohm speaker. Experiment. You could also use a piezo electric device.

The capacitor will be our series component for use with pin RA.2. The major engineering problem with our Tick-Tock circuit is that after about two ticks, Cspk becomes charged and will no longer function. Hence, Rspk which discharges Cspk after each cycle.

You can mount both of these components in holes on top of U-54 if you don't mind cutting one trace. Rspk can be installed in the R11 position. Since we will not be using VR1, these holes are available and directly next to R-11 for use by Cspk. Cut the trace and solder the resistor leads in parallel across Cspk as seen in Figure 3. This is easy to do so be safe and use something like an X-acto knife. Make two tiny cuts across the trace in the middle, about 1/32 of an inch apart (just like on a snakebite), then carefully scrape out the middle piece. One board wears many hats.

There is a cute little miniature loudspeaker which is 1" big, and it is eight ohms. Maybe you can see it in the picture. Although the 12-key keypad PIC Controller has the key click output at pin RA.2, many people will either implement the click elsewhere in their application or not want it at all, so the speaker parts are not included in the complete kit. The Tick-Tock Kit (for 5 VDC) includes the miniature speaker, a 10 uFd electrolytic capacitor, and a

### N & V Wood Shop

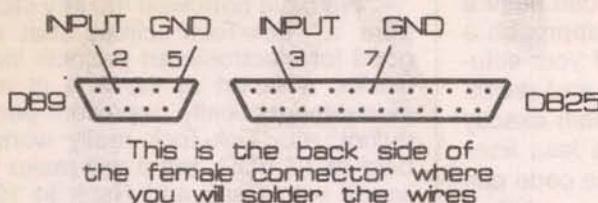
Here is an easy wood project to complement the keypad. Simply cut off a piece of 1x4 pine board 4-1/4" long, bevel the edges, drill out an area in the middle, and it looks like you have actually done something. You may want to stain or paint the thing to match the rest of your house and be color coordinated.

The dimensions and simplicity we see in Figure 5. If you do not own a fancy router, one way to remove stock from the middle is to drill 3/8-1/2" holes (whatever bit you already have) almost touching each other inside the void area, then jerk the thing around on the drill press table until you "wallow" out the area between the holes. This approach isn't too professional, but it will be on the inside which will not show. I don't recommend doing this with a hand drill. You must be certain to support the base firmly when removing material between the holes.

A good carpenter's trick to know for this sort of wood working is to take a utility knife and make a cut about 1/16-1/8" deep on all sides of the area marked to be cut out. This may prevent the bit from breaking out unintended chunks of wood from the cosmetic surfaces.

A mounting facility was not provided for the keyclick speaker here, but it could be mounted in the host apparatus. An enterprising woodcarver could find a way to mount the small speaker and drill a port for the sound.

I have milled my bases to within 1/8" from the bottom of the base, but you could make it less deep and only drill a deep hole right under where the electrolytic capacitor will stick down.

**FIGURE 4 – PC CONNECTION**

4.7 K resistor. It can be ordered if needed.

Crazy art idea — if the keypad is used for security code entry, or whatever, in a somewhat eccentric environment or snooty art project, let the keyclick output control a loud gong, bell, or other sound or an unusual device. (Back in the old days an "unusual device" meant something that could shock the crap out of you!)

#### U-54/56 PC Board Set-up

For this project, we need a crystal timebase, so I have selected a miniature cylindrical crystal (type C2) operating at a frequency of 76.8 KHz, which can be divided down in even multiples to provide exact timing at standard baud rates. It is delicate enough to require about 22 K ohms of series current limiting resistance (RS). Two 10 pF capacitors make a parallel load (C1 and C2).

Be sure to jump your reset pin #4 to +5V if you do not install a voltage detector IC to provide for a power on reset. We can nomenclate

this Rx-out, if you use a resistor. +5V is available at the middle hole for the voltage detector IC. To make life simple, the wires from the keypad go "straight across" to the port RB pins even though the matrix across the bottom

of the keypad is screwed up (out of order).

The software is equally and oppositely screwed up to offset this phenomenon. Does this put your mind at ease?

Once you have wired everything up, the circuit board can be folded back under the keypad and secured there with a piece of two-sided foam tape. You could mount the whole thing in a thin metal box or cut out a wooden base for it.

A standard four-wire phone cord with a standard four-conductor modular phone connector is probably the best and easiest way to provide connectivity. One conductor each for ground, +5V, serial out, and one spare, maybe to pipe the keyclick off the board or mount an auxiliary switch or control in the keypad assembly.

#### PC Test

Let us test our keypad in at least two of its operating modes using our PC. We will test both 1200 and 2400 baud inverted polarity modes. The serial port on the PC

is RS-232 legal which means for one thing, that it relies on a 10-volt swing in both the negative and positive directions for detecting bits.

Oddly enough, the +5 to 0 volt swing of our PIC I/O is usually sufficient to provide accurate byte transmission directly into the PC's port. If you are building keypads exclusively for use with RS-232 ports, you should incorporate an inverting serial line driver IC which will make the +5V signal -10V and the 0V signal +10 VDC.

Attach the grounded lead from the U-54 to pin 5 of a DB9 9-pin serial connector or pin 7 of a DB25 25-pin connector. Attach the serial output lead from pin RA.3 of the PIC to pin 2 of a 9-pin serial connector or pin 3 of a 25-pin serial connector.

Figure 4 shows us where to actually solder the wires. Give the unit a measure of the +5 volt difference of potential.

Evoke a telecommunications program or terminal emulation software on your computer. If pins RA.0 and RA.1 are not grounded, then

set your software for 1200 baud, no parity, eight data bits, and one stop bit. Also, be sure you have the right Comm Port selected in your software as this is the number one cause of serial peripheral related service calls. We don't want to have to get someone to come out and hook the thing up!

After everything is working nicely, try grounding RA.0. Switch your tel-comm set-up to 2400 and try again. You could throw the K-12 in your service kit and use it as a quick and dirty serial port tester.

Now connect the output from U-54 at pad A3 to the pin you will select for serial input on your BASIC Stamp and make the grounds electrical buddies.

Use the BASIC Stamp command "SERIN" to capture your input in the form SERIN (I/O Pin),(Mode), #(Variable). For instance, the line "SERIN 1,N1200,#NUM" will place the number entered from the keypad into the variable "NUM."

Try a few strokes now. Okay. Happy Nuts and Volts! NV

## Parts List

### Semiconductors

**U1:** PIC16C54-XT microcontroller programmed with 12-KEY SERIAL KEYPAD firmware (See Sources.)  
**U2:** 78L05 voltage regulator (Digi-Key# NJM78L05A-ND)

### Resistors

**RPD (7 ea.):** 22K  
**RS:** 22K  
**Rspk:** 4.7K  
**Rx-out:** 220  
**R9-R10:** 10K

### Capacitors

**C1-C2:** 10 pF  
**C3:** .01 uF  
**Cspk:** 10 uF

### Miscellaneous

**Circuit Board:** U-54/56 Universal Pic Carrier  
**Keypad:** 12 Key, 2 of 7 Code

**SO1:** 18 Pin IC Socket  
**X1:** 76.8 KHz, Type C2  
**Spkr:** 8 ohm loudspeaker (if keyclick is desired)

## Sources

### Digi-Key

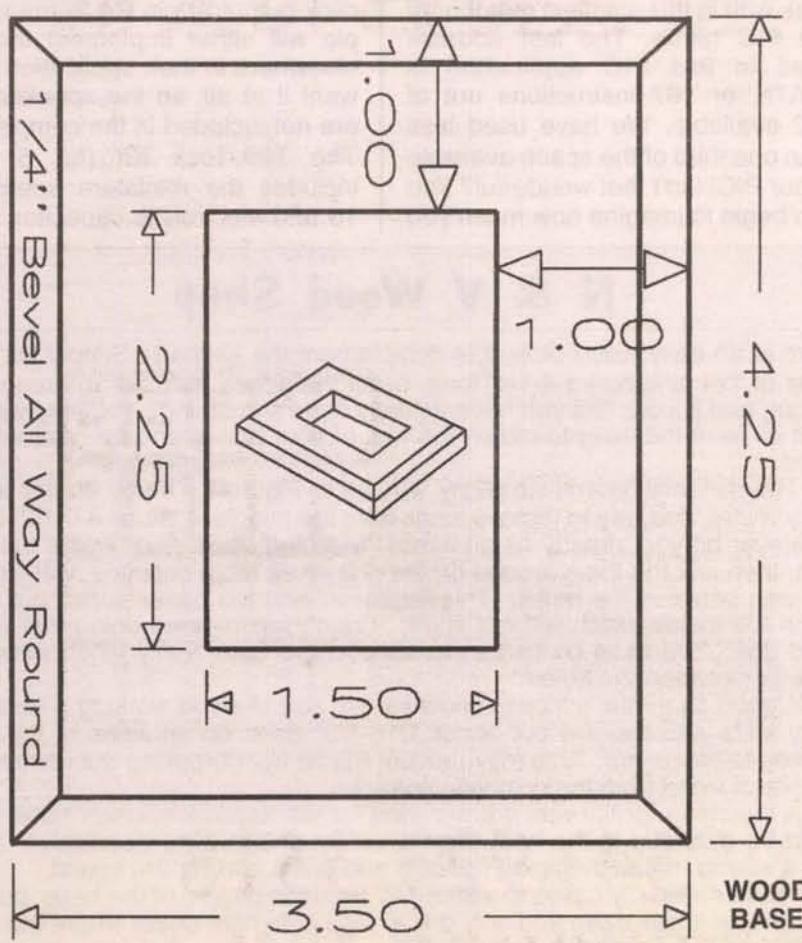
701 Brooks Avenue South  
P.O. Box 677  
Thief River Falls, MN 56701-0677  
Phone (800) 344-4539

### RED ROCK Scientific Supply Co.

P.O. Box ONE  
Red Rock, TX 78662

## 12-KEY SERIAL KEYPAD KITS

**Kit K-12, Complete (less base):** \$20.00 plus \$2.00 shipping  
**Wood Base** \$5.00 + \$2.00 shipping  
**U-54/56 PC Board** \$4.00 ppd  
**76.8 KHz Crystal Parts Kit** \$3.00 ppd  
**Alps 12-Key KEYPAD** \$5.00 plus \$1.00 shipping  
**12-Key Controller, PIC16C54:** \$10.00 ppd  
**Key-Click Kit (NOT included in above kit)** \$2.00+ \$1.00 shipping if ordered separately

**FIGURE 5 – KEYCLICK COMPONENTS**

# COPY CAT

**NEW  
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Soft ware**

**7 way EEE3/9611**

**Soft ware**

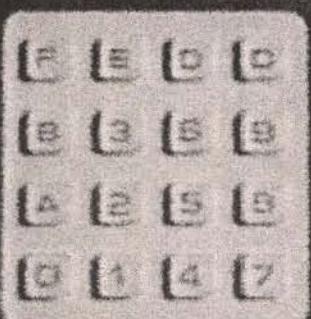
**\$195.00**

**ANY QUESTIONS**

## PROGRAM ESN AND NAM

**COPY CAT**

ESN 82E12345



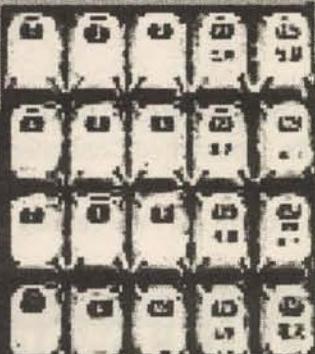
**NEW EEE3**

- 1 MOTOROLLA, EEE3 / 9611  
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9449 /BRICKS:  
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CLASSICS,ULTRA  
CLASSICS 2, CARPHONES  
ANALOG&DIGITAL.
- 2 AUDIOBOX: Audiobox 500 &  
700 &800.850
- 3 G.E./ERICSONS: OLD / NEW  
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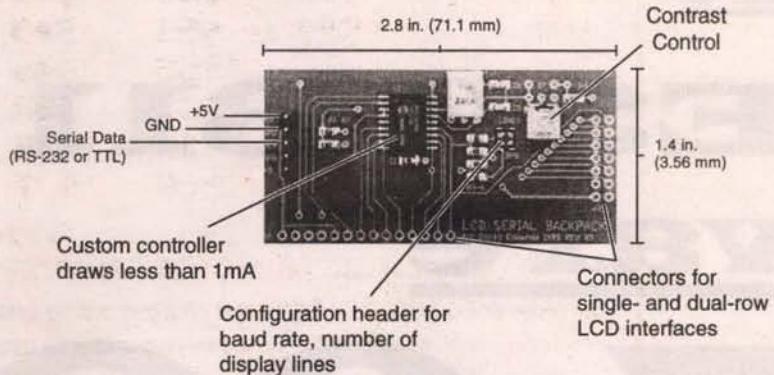
**12864 BISCAYNE BLVD 264 NORTH MIAMI FL 33181**

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## reader FeedBack

Continued from page 6

class, based on an article which was published in a *Popular Mechanics* magazine around that time. (Incidentally, the HV transformer in John's article is incorrectly drawn.)

We used an audio signal (music) through an audio output transformer from tube equipment. This transformer was connected 'backwards' with the low impedance side (8 ohms) to the audio source, and the high impedance side (approx. 5,000 ohms) connected to the flame electrodes and a 400-500 volt power supply, much as in John's article. We did not use the potassium nitrate as John did, but rather common salt or sodium chloride, and managed a

flame length of 20 to 24 inches. It did not produce hi-fi quality sound, but we did consider it a success. We were asked to give a demonstration for a group of physics students of upperclassmen who were also quite impressed. We wanted to try the experiment with a welding torch for a longer and hotter flame, but that didn't seem feasible in our electronics lab. It was a very interesting experience and I was delighted to see this article in *Nuts & Volts*.

Delmer Schlabach  
via Internet

Dear Nuts & Volts:

Thank you for coming on line. I read your magazine every month.

I have followed the BASIC Stamp articles, enjoy and learn from them. I

Dear Nuts & Volts:

Regarding your article "A Road Warrior's Survival Guide." Nice maps, nice charts, but something didn't gel. Is there a chart missing, perhaps?

Jim Tolson  
via America Online

Unfortunately, there is a missing chart, and a chart with the wrong legend. The legend printed is for the telephone services on page 44, not power. The power chart is missing and can be found below, as well as in the library on our Web site. Sorry for the oversight. (<http://www.nutsvolts.com>).

Editor

### Chart Legend

- A. The two-prong plug used in United States and most of the Americas.
- B. This plug has two round prongs and can be used in most of the countries in continental Europe.
- C. Primarily used in Australia, this adapter has two flat prongs like the U.S. plug, but they form a V-shape instead of being parallel.
- D. This plug has three prongs (two flat and one rectangular) that form a triangle, and is widely used in Great Britain.
- E. Plug E is similar to B except the prongs it has two oversized round prongs.

### VOLTAGE GUIDE BY COUNTRY

COUNTRY	VOLTAGE	PLUG
Aruba	110	A
Australia	220	C
Austria	220	B
Bahamas	110	A
Barbados	110	A
Belgium	110/220	B
Belize	110/220	A, C, D
Bermuda	110	A
Bolivia	110/220	A, B
Brazil	110/220	A to E
Bulgaria	220	B
Canada	110	A
Chile	220	B
China	220	B, C
Costa Rica	110	A
Czechoslovakia	220	B
Denmark	220	B
Dominican Republic	110	A
Ecuador	110	A, B
Egypt	220	B
Faeroe Islands	220	B
Fiji	220	C
Finland	220	B
France	220	B
Germany	220	B
Great Britain	220	D, E
Greece	220	B
Guatemala	110	A, D
Hong Kong	220	B
Hungary	220	B
Iceland	220	B
India	220	B, D, E
Indonesia	110/220	B
Ireland	220	D, E
Israel	220	B
Italy	110/220	B
Jamaica	110	A
Japan	110	A
Kenya	220	D, E
Korea	110/220	A, B
Luxembourg	110/220	B
Malaysia	220	D
Malta	220	D, E
Martinique	220	B
Mexico	110/220	A
Monaco	220	B
Nepal	220	B, E
Netherlands	220	B
New Zealand	220	C
Norway	220	B
Pakistan	220	B
Peru	110/220	A, B
Philippines	110/220	A, B
Poland	220	B
Portugal	110/220	B
Puerto Rico	110	A
Romania	220	B
Russia	220	B
Scotland	220	D, E
Singapore	220	B, D, E
Slovakia	220	B
South Africa	220	B, D
Spain	110/220	A, B
Sweden	220	B
Switzerland	220	B
Tahiti	110	A
Taiwan	110	A
Thailand	220	A, B
Turkey	110/220	B
United Kingdom	220	D, E
United States	110	A
US Virgin Islands	110	A
Venezuela	110	A
Wales	220	D, E
Zambia	220	D, E

## reader Feedback

downloaded the articles from the Parallax site and recently downloaded them from your site. I find less problems with your downloads.

**Marcus Morlan**  
NZ8P

Dear Nuts & Volts:

I have been a PCB Designer for 14 years. I found the "Understanding Gerber Files" article VERRRRY outdated and misleading. As did everyone else that I work with.

The article refers to 512-byte block files consisting of 510 characters of data. This format hasn't been used since mag tape days.

The article also refers to "To avoid confusion, there's general agreement on the DOS file extensions for each of the possible layers."

To the best of my knowledge, there is NO such agreement (having spent 11 years in a board shop). There are also files in this list that I have NEVER heard of and no one in this shop has ever heard of.

I suggest you review your sources better before printing additional articles on PCB issues.

**Karen Anne Cardwell**  
**Karen.Cardwell@pii.com**

**Response:**

The article was meant to be helpful to hobbyist/student PCB designers who operate in a time warp of older methods, standards, and software. Shops that cater to them, like A.P. Circuits, still do support the methods and formats described in the article. Don't take my word for it — much of the material was adapted from info files that A.P.C. encourages new users to read and understand. See their web site: [www.apcircuits.com](http://www.apcircuits.com)

Pros working at the cutting edge have of course progressed to better tools and methods. The article wasn't aimed at them. If you're sitting at the controls of a Sun workstation running \$25,000 CAD software, you can't even conceive of the constraints hobbyists operate under. The further you progress in a profession, the harder it is to adopt the perspective of a novice.

If you are really that riled up about the information that you found 'outdated and misleading' (albeit practical and relevant to many Nuts & Volts readers), write an alternative, modern primer on the subject and submit it for publication. Spend some time looking at the output options of sub-\$100.00 PCB CAD software. Contact the PCB houses that cater to the student/hobbyist market. That's what I did.

A final example — many Nuts & Volts readers are avidly interested in toner-transfer PCB fabrication in which laser-printer toner is used as an etch resist. No PCB house would consider such a process, but it's a valid hobby method that generates a few million dollars a year in sales of tools and expendables. It gives a lot of folks an introduction to the

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J. Carton  
Everett, WA

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**Joseph P. Indusi**  
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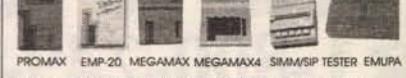
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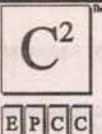
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David P. - CA We called around for help on filters and nobody had any answers except one, call the "THE FILTER COMPANY" we did and had an answer in a matter of minutes.....

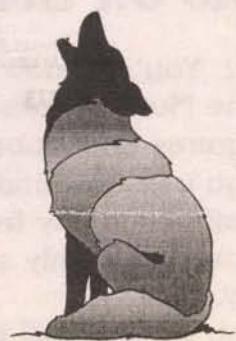
John B. - IL Our company buys in the 100 quantities and needs a large selection of different channels. "The Filter Company" was the only one who was able to supply.....

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Electronics Q & A Continued from page 69

should be stable and from a battery that's separate from either engine (a nine-volt battery would even work if you use the CMOS version of the 556).

### Rating Switch Contacts

Q. My question concerns the current and voltage ratings of mechanical switches and relays. In particular, I was wondering how the ratings translate when your design uses different values. For example, if a switch is rated as 4 amps at 120 volts, what is the current rating at 12 volts? Furthermore, how do AC values relate to DC values?

John Piccirillo  
via Internet

A. The amount of current a wire can carry is proportional to its cross-sectional area; that is, the amount of material you see when you cut it like a sausage. Basically, the more meat you have, the more current it can carry. Switch and relay contacts are the same in that the more metal you have, the more current the contacts can handle. The power rating of the contacts can be estimated by their diameter. Here's a rough guide of contact capacity for AC resistive loads (light bulbs, toasters, etc.).

Contact Diameter	Current Capacity
5 mm	20 Amps
3 mm	10 Amps
2 mm	5 Amps
1 mm	1 Amp

The resistance of closed contacts on a relay that's in good condition is very low — a few milliohms, at most. Consequently, the current rating should be the same whether you're using it for 12-volt or 100-volt loads. However, these values must be derated substantially for inductive loads, like air conditioners and freezers. That's because an inductive load has an EMF backlash, where the collapsing voltage generates a spark that's up to 10 times the voltage of the line feeding it. In effect, you could get a 1,000-volt kick-back from a 110-volt motor. This causes arcing, which can burn the contacts, or even weld them together. In answer to the second part of your question, there are basically two types of current ratings for switch contacts: AC and DC. The AC amperage rating is always higher than the DC rating because the AC signal passes through zero volts, which makes it self-quenching. DC currents, on the other hand, draw arcs, which can destroy a pair of contacts in seconds. In fact, professional welders (you know, the kind that build bridges) prefer DC current at low voltages because it sustains a hot spark which provides a stronger weld. Fortunately, DC currents can be squelched quickly by putting a backward diode or (less favorable) a capacitor across the contacts, which lets it handle higher currents with less damage.

### Used ZDS Computer Parts

Q. I have a Zenith laptop computer model 2WL-183-92 which has a 10 MB JVC hard disk. I'd like to replace it with a good used drive of about 50 MB, but don't know where to look. If that's not feasible, could I use an IDE drive as a replacement with a correct interface card?

Robert Richey  
Vandalia, IL

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## Electronics Q & A

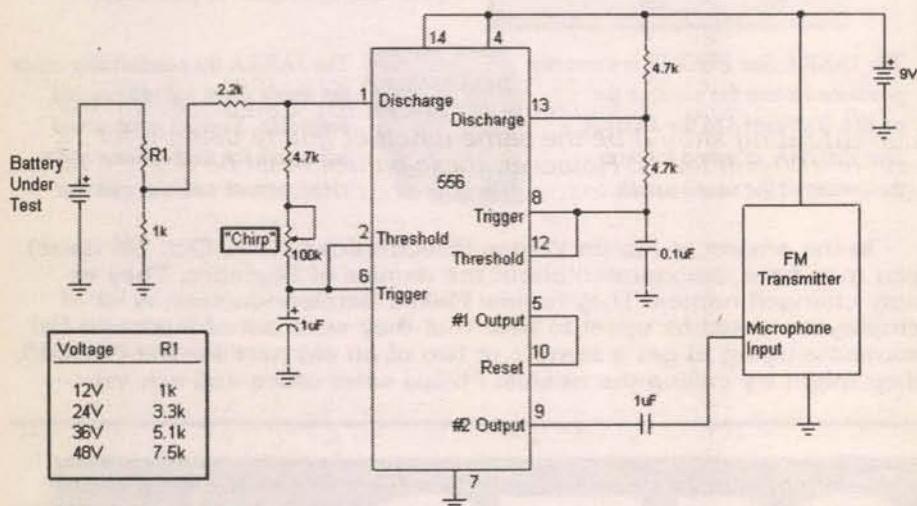
**A.** An excellent source of used Zenith computer parts is **Surplus Trading Corp. (616-849-1800)**. You can find their ad on page 11 of this issue.

## Cricket Alert

**Q.** I'd like a simple way to transmit a voltage reading via radio to a remote display. The actual application is to monitor the battery voltage of my electric car from my apartment so that I don't have to go down to the carport to check its progress. The straight-line distance through the floor is about 20 feet. I'm kinda leaning toward a wireless connection because while I know AC powerline transmission would be a possibility, I suspect there may be a problem with charger hash.

**Chuck Hursch**  
Larkspur, CA

**A.** I have a novel thought on this one. Have you heard the story about the cricket and temperature, where you can gauge the temperature by counting the number of chirps a cricket does in a minute? Why not apply that to your electric car? The fuller the charge, the more frequent the chirps. Fewer chirps means a low battery. This is easily done using a low-power FM transmitter in the car and an alarm-clock FM radio. Here's a simple circuit that takes almost no power. You can buy the FM transmitter from many of our advertisers, or build your own (I've printed about a million of them).



The left side (multivibrator #1) of the circuit is a pulse generator. As the voltage of the battery increases, the pulse rate increases, too. The right side (multivibrator #2) of the circuit is a simple tone source. When the output from multivibrator #1 goes high, it resets circuit #2, which emits a tone that is sent over the air waves by the FM transmitter. The duration of the tone is controlled by the width of the pulse, which is set by the "chirp" adjustment. You can change the pitch of the chirp by experimenting with the 0.1 uF

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G7370 \$5.00

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#### HANDY MULTIMETER VOM

Made by GB this handy pocket sized multimeter tests AC volts from 0-400V, DC volts from 0-400V, DC Current from 0-200mA, resistance from 0-20 MegΩ. The neat aspect of this meter is that it's only about 4" x 2" x 3/8" thick and it has built-in probes and a protective case. Features autoranging, 3.5 digit LCD readout, data hold button and comes with 2 watch batteries for power. Brand new in retail packaging. Model GDT-800. Accuracy: ±2% of reading ACV, DCV, ±5% of reading in ohms.

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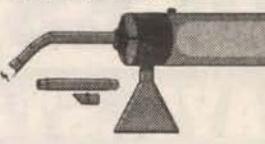
Low current high reliability TI case red LED by Stanley. 6mcd@20mA typical output. Pastel diffused pinkish lens type. Peak wave length: 630nm, V<sub>r</sub>-2.0V. These are brand new and very nice!

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#### FUTABA INTELLIGENT ALPHANUMERIC DISPLAY

Brand new 2 line with 16 characters on each line alphanumeric display. These glow bright blue and are the fluorescent glass type displays. The Futaba part# is, we believe, 162SD003C. Attached to the display is a circuit board containing 3 IC's and a driver circuit. The IC's are two OKI C1162's and one Intel N8852AH. We have absolutely no data or hookup info. We can tell you that it has five hookup pins on one end. These are brand new in manufacturer bags and if you can figure them out you'll save a bundle!

G7875 \$2.95

#### BRILLIANT OUTPUT BICYCLE/JOGGER WARNING LIGHTS

These small warning lights operate from 2 AA batteries (not included) and produce brilliant flashes of light to warn approaching motorists of your presence. Clips onto belt at the back of your bicycle seat with the built-in clip. These appear to be brighter than the popular rectangular units that we have seen and we are selling them for much less. Size: Approx. 2 3/4" dia. x 2" thick. Brand new in retail card packaging. We have two types!

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Also includes a data hold button and comes with a handy carrying case. Size about 6 1/4" L x 1 3/8" W x 13/16" D. Brand new in retail blister pack. These are worth at least \$50!



Write in 206 on Reader Service Card.

Nuts & Volts Magazine/November 1996 115

capacitor's value. One precaution, never let the input voltage from the battery under test go higher than the nine-volt power source (that's the reason for R1). Have fun!

### Advertising Giant

**Q.** My grandson wants to build a movable message display large enough to display messages between 3 feet and 10 feet long, with letters of 5 to 12 inches tall. The message can scroll, but it should be able to hold one double-spaced standard page of text. Control of the displays should be as simple as possible; ideally, from a keyboard. The proposed locations for use of the display are fences, a parked vehicle, and buildings. Could you please supply the addresses of businesses that sell equipment for building such a display?

Bud Blomberg  
Indiana, PA

**A.** This is a pretty tall order. However, I was able to locate two companies that sell these items for a "reasonable" price (under \$1,000.00). The first is **Forward Enterprises**, Alberta, Canada (403-289-1717; <http://www.spannet.com/signs/>). The other is **Acefair Industries**, but their main office is in Hong Kong, so you'd be smart to contact them via their Internet address (<http://home.hkstar.com/~acefair/home.html>) and look over their products first. There are others, like Mitsubishi, but they're more expensive.

### Needs UPS Software

**Q.** I have a computer back-up power supply made by American Power Conversion, with the model name Smart-UPS 400 (120V). It has a serial port and dip switches in the rear. I know it can monitor AC power levels, surges, dips, etc., but the person who gave it to me can't locate the software or manual. Any help locating software would be appreciated. The manual isn't necessary, just the switch settings. Also, can these units be adapted for extended use from the battery supply (as in larger battery capacity and added cooling)?

Don Edwards  
via America Online

**A.** Maybe the reason he didn't give it to you is because he

never had it. The program you're looking for is PowerChute Plus, and it costs \$69.00. You can see a demo of it in action at APC's Web site (<http://www.apcc.com/english/prods/index.htm>). In fact, they have a whole range of software and hardware add-ons for your Smart-UPS.

### Mailbag

Dear TJ:

Two items. There's an outfit in San Diego, CA (<http://www.jabra.com>) called Jabra Corporation that makes an ear microphone that goes both ways, and has good noise immunity (see Figure below).

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The JABRA fits comfortably inside the user's outer ear utilizing our earmolds. You get great sound input with the microphone and clear, private audio in your ear.

In the answer to Martin Vargas (Electronics Q & A, Oct. '96 issue), you may have exaggerated about the demise of Signetics. They've only changed names. They're now Philips Semiconductors. A lot of employees would be upset to hear that they went out of business! For someone trying to get a sample or two of an old part like the NE5045, they might try calling the nearest Philips sales office and ask very

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nice for a sample. If one is laying around the office, I'm sure they'd part with it!

**Kellybob1**  
via America Online

## Response:

Thanks for the two tips. I'm sure they'll be helpful to our readers. Sorry, if I stepped on anyone's toes, but if you're looking for Signetics parts, you're not gonna find them under the old name.

**TJ Byers**  
Q & A Editor

Dear TJ:

The August issue had a couple of questions for which your answers have been bothering me, and I'd like to ask you about them. The one was titled "It's always 12:00 at my house," a question about how to deal with power outages and electronic equipment that have no back-up for stored information, like the time. Your answer was to use three alkaline cells to maintain power to the five-volt supply line in the device, using a 1N34A to make sure that electricity would only flow from the batteries, and not to them. The batteries generate 4.7 volts, but won't the diode produce a voltage drop of 0.7 volts, leaving only 4.0 volts? Is this really enough? Could an alternative solution be to use a six-volt lead-acid battery or two three-volt lithium cells, in series with two diodes to keep the voltage below five volts?

My second query is about the amateur rocketry question. The writer complained about his batteries not lasting very long with regular igniters, and he wanted a substitute for the igniters. I think another way to tackle the problem is to find a way to boost the output from the batteries so that they last longer. For instance, use a DC-to-DC step-up converter, something like the Maxim 1771, so that even as the batteries drop in voltage, the voltage to the igniters remains high.

**Tom Harrison**  
via Internet

## Response:

First question: Yes, it's enough because the 1N34A is a germanium diode with a voltage drop of 0.3 volts, not 0.7 volts. The end voltage, with fresh batteries, is somewhere around 4.5 volts. The

voltage of a lead-acid battery (typically 6.3 volts) is too high for this application, even with two dropping diodes, and the lithium cells are short-lived. About the igniters: It's a matter of power, not voltage. As you know, power is equal to the voltage times the current ( $P = E I$ ). Increasing the voltage means you lower the current. His problem is that the igniters, which are basically a filament wire, drain his battery way too soon. No amount of changing voltages can fix that.

**TJ Byers**  
Q & A Editor

Dear TJ:

In your answer to Eric about solar powered-sprinklers, you neglected to show a blocking diode. Without it, the solar cell will drain the battery of its charge overnight. I use a similar solar set-up to power remote weather stations accessed by cellular phones and modems.

**Jimmy Qualls**  
via Internet

## Response:

Yes, I should have included the diode just to be safe. In many of my designs, though, I've been able to get away without them, but it depends on the panel and the balance between it and the battery. Stay tuned for more on solar projects. Looks like I struck a chord on this topic.

**TJ Byers**  
Q & A Editor

## Reader's Tip

I just read the request for Spice models for RF devices. As you doubtless know, most IC manufacturers have Web pages with numerous Spice models on them. What you may not have noticed is that very few of these are for RF devices. So I scoured the Internet and concatenated the scattered RF models into a single file.

**Dave Hayes**  
via Internet

You can find this file on the Nuts & Volts Web site, in the FTP Main library, under the name RFSPICE.ZIP. (<http://www.nutsvolts.com>)

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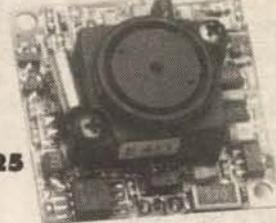
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# BUILD THE SCOPE BOOSTER

*Increase the Frequency of Your Oscilloscope to 170 MHz*

by Henry Wolf

**H**ave you ever used an oscilloscope to tune the output of a power mic, so that it was perfect, no distortion, no clipping? (The signal was as clean as it could be, then you transmit to someone using that same mic and they say, "You sound distorted.") Have you ever built a power booster for your CB or ham radio and then find out that your signal no longer sounds clear? Have you ever built a small oscillator to use as a transmitter, but could not find out if the distortion was in the oscillator or modulator?

If you have problems like these, the Scope Booster is the project for you.

With the use of the Scope Booster, you can display a high-frequency RF signal directly on your oscilloscope screen, without the use of a high-frequency oscilloscope. The Scope Booster is an easy-to-build, high-performance accessory for your low-frequency oscilloscope. With the help of the Scope Booster, you can measure frequencies from 4.2 to 170 MHz. The circuit board construction is straightforward and well thought out. A novice kit builder should have no trouble building this project with its easy to follow, step-by-step instructions.

## Theory of Operation

In the block diagram shown in Figure 1, the device under test is connected to the Scope Booster, which itself is an RF mixer and buffer amplifier. Here, the signal being tested is mixed with the signal from an RF signal generator. For example, if you are testing a 27.55 MHz CB transmitter, you simply set the signal generator to 28.55 MHz; the mixer will combine these two frequencies, its output will

be the difference between them. In this case, a 1 MHz signal goes directly to the vertical input terminals of your scope for viewing.

When testing higher frequencies — such as a 100 MHz transmitter — it is better to use a higher conversion ratio. For example, if you have a 5 or 10 MHz scope and are testing a 100 MHz transmitter, set your RF signal generator to either 96 MHz or 104 MHz; this gives you a 4 MHz conversion. If you only have a 1 MHz scope, set it so you have four cycles on the screen. The reproduced signal is identical to the original. Any distortions, such as second harmonic, non-linear amplification, and over and under modulation, also appear exactly as the original. Figure 2 shows some examples of these

types of distortion.

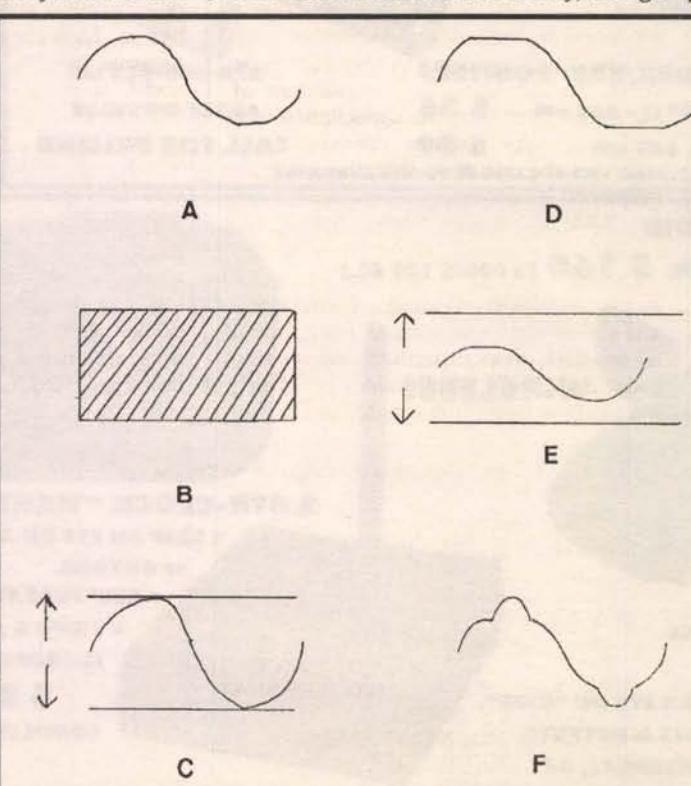
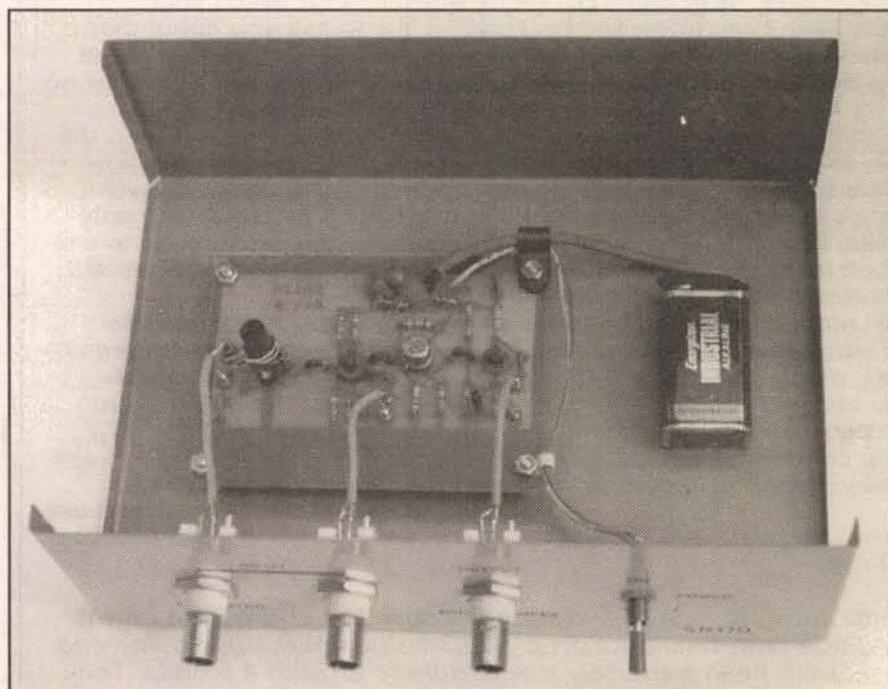
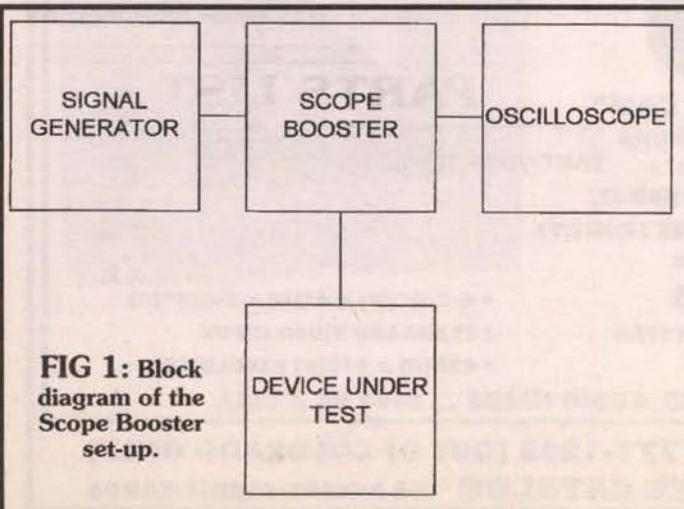
It should be noted that, when mixing two sinewaves, you not only have the difference between them, but also the addition of them on the output. A 27 MHz signal mixed with a 28 MHz signal gives four outputs: 27, 28, 1, and 55 MHz. No filtering is necessary since your scope cannot see frequencies beyond 10 MHz. Now that we have a little theory, let's go

over the circuit used in this application.

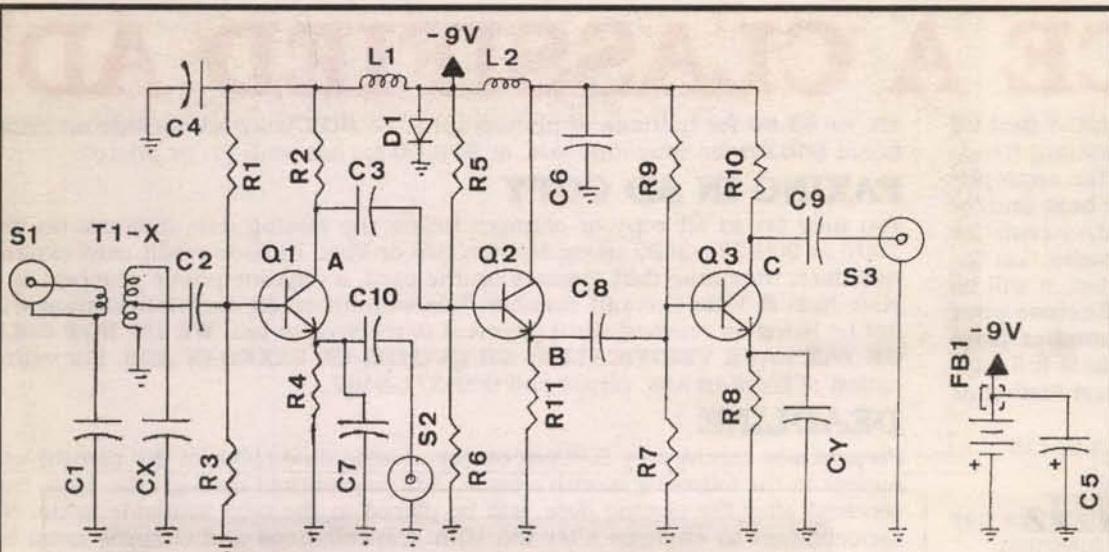
## Circuit Description

The Scope Booster circuit diagram is shown in Figure 3. The bias of mixer transistor Q1 is set by resistors R1, R3, and R4; R4 is bypassed to increase AC gain. The output of your signal generator is matched to the input of Q1 by transformer T1. Transformer T1 is tapped one turn from the bottom to prevent overloading and frequency drift. Capacitor C2 couples the signal to the base of the mixer. The signal being tested is injected directly into the emitter of Q1 through capacitor C10. The output is taken from load resistor R2 and coupled using capacitor C3 to the base of the buffer. Transistor Q2 is a very low noise, highly stable, transistor which provides almost no load on the mixer.

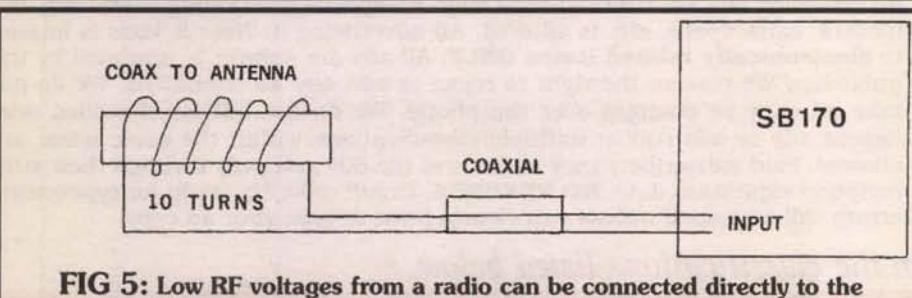
Bias of Q2 is accomplished by resistors R5, R6, and R11. The output of the buffer stage is amplified by transistor Q3 which is biased identical to Q1. Capacitor C8 couples the output of the buffer to the input of Q3. The output signal is taken from load resistor R10 and coupled to the output connector through capacitor C9. Capacitors C4, C6, and RF chokes L1, L2, and FB1 provide high-frequency filtering of the power supply. Capacitor C5 is a high-value tantalum capacitor used to prevent the circuit from becoming a low-frequency audio oscillator. Diode D1 protects the circuit from accidental polarity reversal when power is applied.



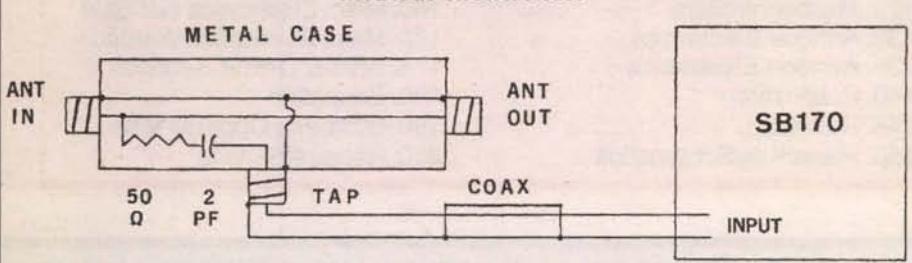
**FIG 2:** Output Wave Forms. (A) 400 Hz test tone. (B) RF viewed at audio sweep rate. (C) Perfect modulation. (D) Severe clipping of the RF signal. (E) Under modulation. (F) Distortion of the RF signal.



**FIG 3:** Schematic diagram of the Scope Booster. The Scope Booster requires no internal connections. It just plugs directly into the vertical input terminals of your oscilloscope.



**FIG 5:** Low RF voltages from a radio can be connected directly to the booster. When connecting the output of the transmitter, use one of the methods shown here.



Now that we have a little understanding of the circuit, let's build one.

### Circuit Construction

The use of a printed circuit board is important due to the high frequencies involved; fiberglass or phenolic is best. Next is component selection.

First, we must determine what frequency range we would like to cover. Let's say we want to test a 100 MHz FM radio transmitter; look at the chart in Figure 4. The chart is broken down into five columns. Frequency Range in MHz, T1, Primary Turns, NPO CX, and Mylar CY. Note: The chart in Figure 4 is only a partial chart which covers frequencies from 66 MHz to 170 MHz. A full chart is included in the kit which covers a frequency range from 4.2 MHz to 170 MHz.

Look down the column that says

"Frequency Range," — 88 to 108 covers the range that is needed. The next column gives the coil number needed for T1. Now look across to determine the number of turns needed for the primary of T1, followed by the value of CX and CY.

All resistors should be carbon composition 1%. Metal film resistors have a tendency to look like inductors at high frequencies. Capacitor CX should be type NPO. As the operating temperature of the circuit increases, the capacitance of a NPO capacitor remains constant. This stabilizes the circuit so that the resonant frequency is constant.

All bypass and coupling capacitors are ceramic type, grade Z5U or better. Capacitor C5 must be tantalum because of its low impedance. Transistor Q2 is critical and should not be substituted. First, mount all resistors, then capacitors, followed by coils, and finally semiconductors. Watch the positive polarity on capacitor C5 and

in this case) around the coil on T1, bring the other end through its hole in the PC board, and solder it.

All input/output connectors should be type BNC. The kit uses silver plated Teflon® coax cable when connecting them to the PC board; standard coax may also be used. When installing the braided shield, make sure there are no loose wires sticking out of the top of the board or at the base of the connectors. These loose wires will act as antennas at different frequencies.

Next, install inductors L1 and L2. Finally, before soldering on the battery snap, be sure to slip the ferrite bead over the negative lead which is always the black wire. Clean all rosin off the board with flux remover.

Assembly is now complete. We will now learn how to test and use the Scope Booster.

### Testing and Using the Scope Booster

Before applying power, measure the resistance across the terminals on the battery clip, then reverse the meter leads and read it again. They should read 6.2K in one direction and 2K in the other. Next, use a high-impedance voltmeter and measure the DC voltage at points A, B, and C to ground on the schematic. The voltage should measure 4.8 volts, 1.5 volts, and 4.8 volts, respectively.

If any of the readings are greater or less than 20%, stop, check all component values and their location. Also check for solder bridges and broken connections. If all is well, no further tests are required. Use a nine-volt standard battery to power-up your Scope Booster. If you decide to use a power supply, it should first be tested using the battery. Then switch over to a regulated nine-volt DC

Frequency Range in MHz	T1	Primary Turns	NPO CX	Mylar 5% CY
68 to 88	T1-C	1	24 pF	.001 uF
88 to 108	T1-C	1	18 pF	.001 uF
108 to 120	T1-C	1	10 pF	.001 uF
120 to 145	T1-C	1	6.8 pF	.001 uF
145 to 170	T1-C	1	5 pF	.001 uF

**FIG 4:** Component Specification Chart.

diode D1.

Installing the primary link on transformer T1 is simple. First, cut a piece of small gauge wire such as #24 or #26 (or anything handy that is insulated). Tin one end first and solder it into the board. Now, wrap the required number of turns (one,

power supply. Now we are ready to test our 100 MHz FM radio transmitter.

Never connect the output of a power transmitter directly to the Scope Booster; use one of the taps as shown in Figure 5. Now connect your signal generator, the device under test, and your oscilloscope to the Scope Booster. Set your scope to a horizontal sweep rate of .2 uS per division. Slowly adjust the frequency of your signal generator above or below 100 MHz until you obtain the largest signal on the scope screen.

Using a plastic tuning tool — anything else will throw the circuit off — slowly adjust T1 until you have a maximum undistorted signal. Re-adjust the signal generator once again for maximum output on the scope. The Scope Booster is now complete. It should be mounted inside the metal case to keep stray RF fields from affecting its operation.

Figure 2 contains some examples of output wave forms. In Figure 2A, a 400 Hz test tone is displayed. This would be the output of your power mic. Figure 2A is also the output of the transmitter with no modulation — a perfect sinewave pattern of 100 MHz which you now see on your scope, thanks to the Scope Booster.

Figure 2B is the image you get with a low-horizontal sweep rate. This is used when viewing audio without the use of an RF demodulator probe. The RF pattern appears as a solid green rectangle. The wave form in Figure 2C is perfect modulation. The example in Figure 2D shows severe clipping of the RF signal caused by over modulation. Figure 2E shows a clean signal, but under modulated. Finally, Figure 2F shows a wave form with distortion of the RF signal.

By using the techniques described in this article, you can use your scope to view any RF frequency up to 300 MHz. Any frequency beyond 300 MHz can be viewed by using a method called double conversion. For example, if you want to test a 420 MHz signal, first mix it with 320 MHz; this gives you a 100 MHz output from mixer one. Then using a second mixer, mix the 100 MHz output with a 99 MHz signal. This gives you a 1 MHz output signal on your scope. A second signal generator is not necessary. A simple 100 MHz crystal oscillator will do the trick. Complete details are available in the kit manual from Creative Technology. NV

### SEMICONDUCTORS

Q1, Q3  
Q2  
D1

### CAPACITORS

C1, C3, C4,  
C6, C7, C8,  
C9, C10

C2

C5

CX, CY

### COILS

L1, L2  
FB1  
T1-A, B, C

### RESISTORS 1/4 watt 1% CARBON

2N3906  
2N4931  
1N4002

### MISC.

BNC BULKHEAD CONNECTORS  
NINE-VOLT BATTERY SNAP  
PC BOARD  
MOUNTING HARDWARE  
METAL CASE  
COAX CABLE

10K OHMS  
1K OHMS  
3.3K OHMS  
350 OHMS  
150K OHMS

#CT1081

### PART#/DESCRIPTION

#CT1081

Scope Booster Printed Circuit Board \$15.00.

SB170K

Complete Scope Booster Kit \$59.95. Includes circuit board, complete set of coils and capacitors to cover the 4.2 MHz to 170 MHz bands, and all other parts including a 50-page instruction manual on how to use your scope booster.

SB170B

Assembled and tested Scope Booster (specify test frequency when ordering) \$79.95.

1.2 uH  
FERRITE BEAD #CT0213  
RF TRANSFORMER SET  
#CT1084-3

Note: The following items are available from Creative Technology, Dept. NV, 206 Gilbert Ave., Winsted, CT 06098. Add \$3.50 for shipping and handling on all orders. CT residents add state sales tax.

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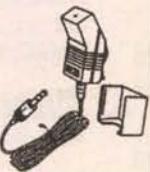


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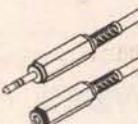
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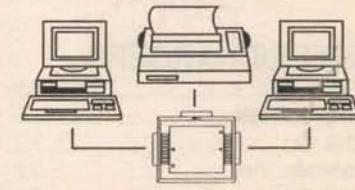
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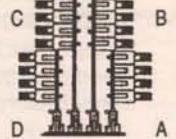
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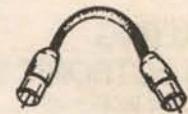
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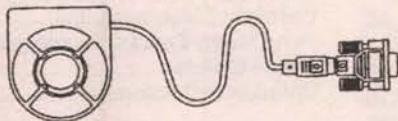


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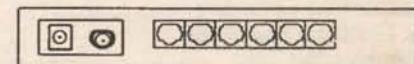
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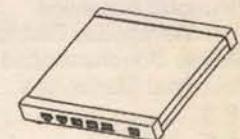
6 RJ-45 Ports BNC Input  
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#TM-TBT-HUB6 \$69.00 each

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Five outlet-Surge Protected  
Phone/Fax/Modem  
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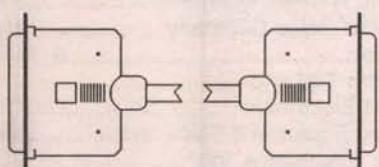


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Instruction manual



#TM-290-Mini  
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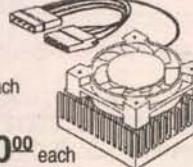
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Easy power hook-up! Works with ZIF Socket. Clips to Chip.

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#TM-FAN-2 486 CPU \$5.00 each

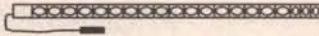
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Ball Bearing

#TM-FAN-90BB Pentium CPU, 75-150 MHz \$10.00 each



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12V DC • 16" long w/6" lead



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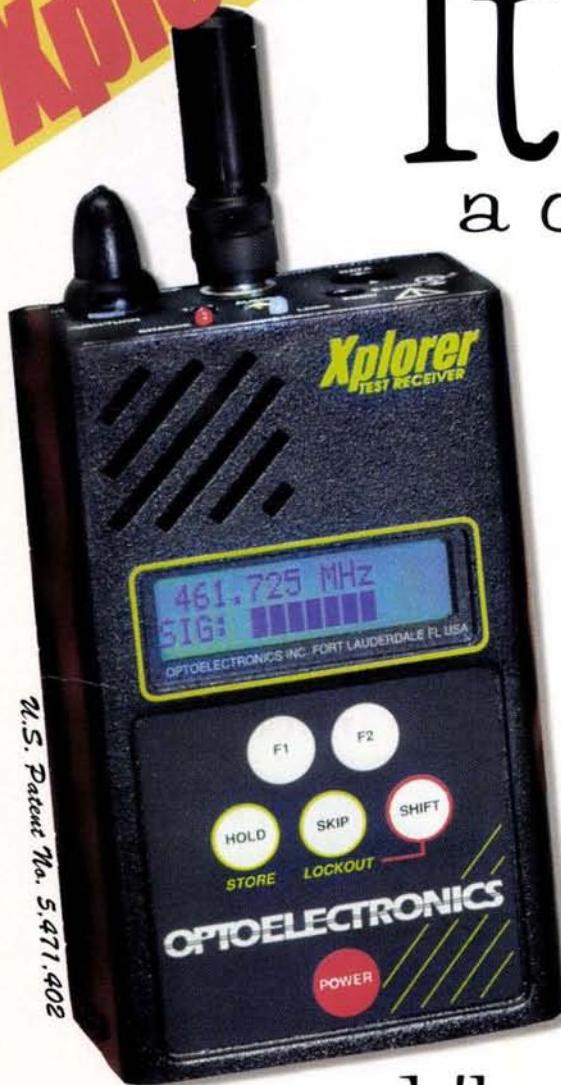
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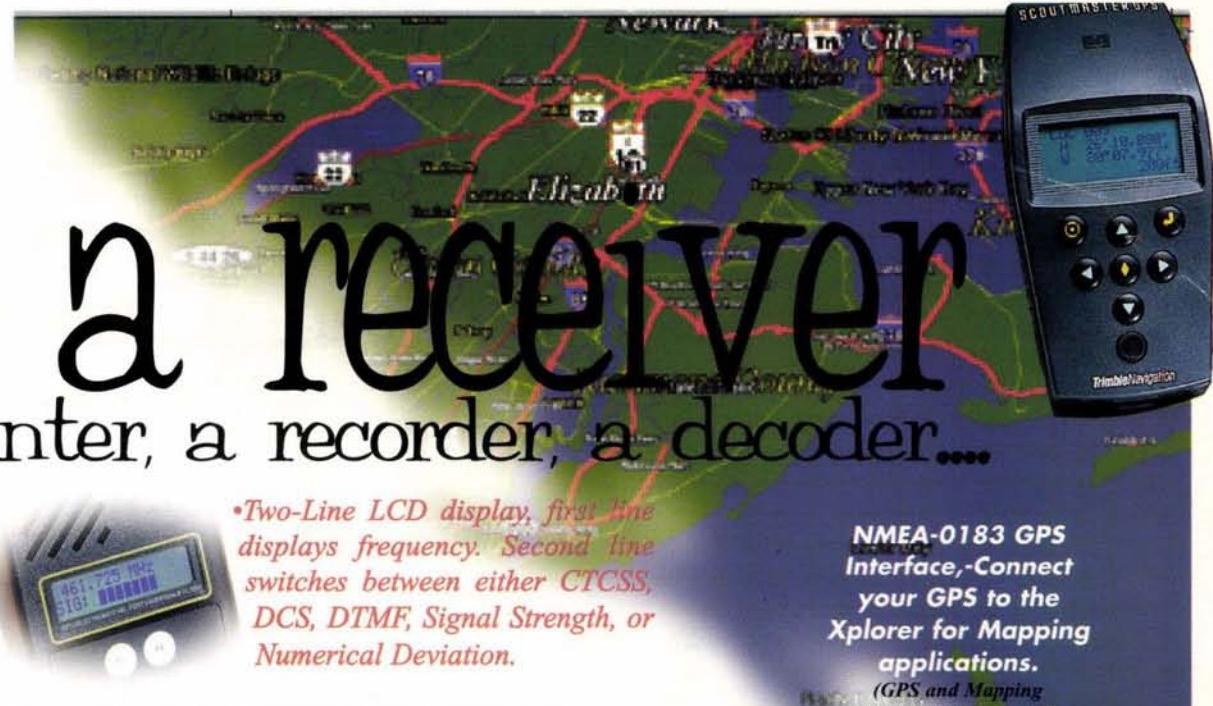


**NEW  
Xplorer**

# It's a receiver a counter, a recorder, a decoder....



U.S. Patent No. 5,471,402



- Two-Line LCD display, first line displays frequency. Second line switches between either CTCSS, DCS, DTMF, Signal Strength, or Numerical Deviation.

NMEA-0183 GPS  
Interface - Connect  
your GPS to the  
Xplorer for Mapping  
applications.  
(GPS and Mapping  
Software not included)



- Built-in Speaker: All frequencies received are demodulated for instant monitoring.

and the last instrument you will ever NEED.

## Features & Specifications

- Frequency Lock Out, Manual Skip, and Auto or Manual Hold
- Internal Speaker, Audio Earphone/Headphone Jack
- Built-in PC Interface, PC Connection Cable and Download Software included
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- Optimum Maximized Sensitivity for increased nearfield distance reception
- Tape Control Output with Tape Recorder Pause control relay and DTMF Encoder for audio data recording
- High speed FM Communications Nearfield Receiver, sweeps 30MHz - 2GHz in less than 1 second
- Two line LCD displays Frequency and either CTCSS, DCS, DTMF, Deviation or Signal Strength
- NMEA-0183 GPS Interface provides tagging data with location for mapping applications
- Frequency Recording Memory Register logs 500 frequencies with Time, Date, Number of Hits and Latitude/Longitude. *(Latitude & Longitude coordinates are only displayed in memory when used with GPS)*
- Real-Time Clock/Calendar with lithium battery back-up
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- Numerical Deviation Display with 1-10kHz and 10-100kHz ranges
- Telescoping Whip full range Antenna included



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16 I/O lines	
500 instructions max.	
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50k baud serial I/O	
24-pin DIP module	

Same I/O instructions as BS1, plus touch-tones, frequency generation, pulse counting, serial shift registers, X-10 powerline control, etc. I/O functions common to both modules have a higher resolution on the BS2-IC, due to its faster clock speed.

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Contains items needed to program BASIC Stamp modules; includes cables, PC software, manuals, and free technical support.	

<b>Carrier Boards</b>	<b>\$15-\$20</b>
Provide small prototyping area, 9-volt battery clips, and programming connector. Not absolutely necessary, but recommended to make programming and experimentation easy.	

<b>New! 4-line Serial LCD</b>	<b>\$109</b>
New 4-line serial LCD display is fun and useful for projects that require interaction with people. The display only takes one I/O line to operate, and can be controlled using simple SEROUT instructions in your BASIC Stamp programs.	



FaxBack #6004



Charles Walsh and his students in Great Falls, Montana, use BASIC Stamps in robotics projects.



Marvin Green and his students in Hillsboro, Oregon, use BASIC Stamps to make small robots.



John McLean uses BASIC Stamps to gather data in Lechuguilla Cave (America's deepest cave, located in Carlsbad Caverns National Park).



Although it may be difficult to see here, that's a BS1-IC next to the white wires.

Issac Kurtz and John Bishop use BASIC Stamps in artificial bands at the Bloorview MacMillan Centre in Toronto, Canada.

## BASIC Stamp discussion list on the Net!

The list works like this: lots of people (currently 900) subscribe to the list, and then all questions and answers to the list are distributed to all members. It's a fun, fast, and free way to discuss BASIC Stamp issues.

To subscribe to the list, send email to [majordomo@parallaxinc.com](mailto:majordomo@parallaxinc.com) and write **subscribe stamps** in the body of the message.

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